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[SECOND SERIES.]

ART. XXXI.—*Remarks on the Huronian and Laurentian Systems of the Canada Geological Survey;* by J. D. WHITNEY.

FROM some of the most recent publications of the Canada Geological Survey it appears that Mr. Logan, the able director of that survey, holds certain views in regard to the position of the lowest rocks in the northwest, which differ from those which have been maintained by Mr. Foster and myself as the result of our examinations in that region, made under the authority of the United States government. Having enjoyed opportunities for part of two additional seasons of exploration in the vicinity of Lake Superior since the completion of our geological survey, it seems proper to endeavor to throw some additional light on the points in dispute, especially as the matter is one of considerable practical importance to the mining interests of that region.

All the geologists who have made any extended examinations in the northwest are agreed in opinion in regard to the age of the great sandstone formation which covers so much of the territory around Lake Superior, and spreads out over so large a portion of Wisconsin and Minnesota. It undoubtedly forms the base of the fossiliferous series, and is the equivalent, or continuation rather, of the Potsdam sandstone of the New York geologists. Beneath this sandstone, and unconformable with it, we find an immensely-developed series of slates, quartz-rock, &c., to which we have given the name of the AZOIC SYSTEM. This system embraces all the rocks lying beneath the lowest fossiliferous beds in

the northwest, from which the azoic rocks are easily distinguished by marked differences of lithological character, and by unconformability of position.

Mr. Logan, however, recognizes two distinct systems below the Potsdam sandstone, and to which he has given the names of Huronian and Laurentian, thus differing from Mr. Foster and myself, who have admitted the existence of only one. If we examine the published reports and maps of the Canada Survey, we find this discrepancy of opinion to be due entirely to a different understanding of the origin and relations of the cupriferous formation of Lake Superior, and especially of that portion of it which belongs to the southern shore of the lake, within the limits of the State of Michigan. If we follow Mr. Logan, we admit that the series of sandstones, conglomerates and bedded traps forming the cupriferous belt, which extends from the extremity of Keweenaw Point to the west beyond the Montreal River, lies unconformably beneath the sandstone which shows itself along the south shore of the lake, almost uninterruptedly from its outlet to its western extremity. We must also admit that these cupriferous rocks are identical in age with the series of quartz, beds, and jaspery conglomerates displayed on the north shore of Lake Huron, and hence called "Huronian." Therefore, according to Mr. Logan's views, since the cupriferous series of Lake Superior rests unconformably on a still lower formation of slates, quartz-rock, &c., the rocks of Lake Huron must also do the same, although no such fact has been observed. Hence we must recognize two systems beneath the Potsdam sandstone; one, the Huronian, comprising the cupriferous rocks of Lake Superior and the formations of the north shore of Lake Huron, the other, the Laurentian, including all the rocks of Canada and the northwest which we should designate by the term "Azoic," with the exception of those of Lake Huron as before indicated.

The principal question to be settled, then, is this; what are the relations of the cupriferous rocks of Lake Superior?—do they constitute a distinct system by themselves, or are they part and parcel of the Potsdam sandstone itself? If they are only a local modification of the Lower Silurian sandstone, then they ought not to be removed from the place to which they belong, and they certainly cannot be made the basis of a new system. And if this is not done, then there is no proof of the existence of two unconformable systems beneath the Potsdam sandstone, since there is no evidence, either lithological or stratigraphical, for separating the rocks of Lake Huron from those which occur farther east, and which are classed by Mr. Logan as Laurentian.

The sandstone of the northwest, the base of the fossiliferous series, which is, as usually seen, three to four hundred feet in thickness, is made up of a coarse grained and rather friable grit,

consisting of fine grains of quartz, with but little cement between the particles, and slightly colored by oxyd of iron. It is distinctly stratified, the layers varying in thickness from a few inches up to two feet, and having a very slight dip, which is in general to the south, with many minor undulations. From the extremity of Keweenaw Point, however, extending to the west for a distance of over 150 miles, we find a belt of rocks inclined at a considerable angle to the horizon and made up of alternations of trap, sandstone and conglomerate, which together have a thicknes of several thousand feet. The culminating portion of this belt consists of one or more ridges of trappean rock which rise in some places to a height of nearly a thousand feet above the level of the lake. The south side of the ridge usually presents a mural escarpment, sometimes 300 or 400 feet in perpendicular height. On this side of the cupriferous belt we find the sandstone dipping at a considerable angle in close proximity to the trap, but at a little distance from it acquiring its normal position and appearance. The deep adit-level, at the Norwich Mine, driven for 439 feet at the base of the trap range on its south edge, displays a most instructive section of this portion of the formation and shows conclusively that there has been an upheaval of the rocks to the north, along a line of fracture extending nearly east and west, while the region to the south was only slightly affected. The adit-level commences in the conglomerate which flanks the trap-range on the south. For twenty-four feet from its mouth, the rock excavated is conglomerate, without any recognizable bedding; then follows sandstone for fifty-five feet, which shows in the most marked manner the mechanical action by which the trap was uplifted. It is broken and crushed into fragments, which afford the most evident proofs of having been rubbed against each other with immense force, at the time the upheaval took place. The next 52½ feet are occupied by trap, the southern portion of which is distinctly observed to dip to the south, although evidently much crushed and dislocated during its uplift, while the northern half has a steep inclination to the north. Nothing can be clearer than the evidence which is here afforded of a fracturing of the strata, and an immense mechanical force exerted in the upheaval of their northern portion. At about 130 feet from the entrance of the adit, is another belt of sandstone, which is about thirteen feet thick and has apparently the regular dip of the beds of rock in which the mine is wrought, about 44°. From this section, as well as from numerous other observations made along the southern line of junction of the cupriferous belt and the sandstone, it is evident that the latter participated in the uplifting movement of the trappean belt, and that it was not subsequently and unconformably deposited at its base.

In regard to the sandstone on the north side of the trap range, the evidence is equally clear that it cannot be separated from it, either lithologically or stratigraphically. Towards the eastern extremity of Point Keweenaw the sandstone is not exposed on the shore of the lake, having been washed away, but conglomerate and trap make their appearance and occupy the coast on the north side of the Point, to the distance of five miles west of the mouth of Eagle River. From this point onward, the sandstone appears in strata dipping at a low angle to the north and resembling in lithological character that which forms the shore of the lake from Saut Ste. Marie to the Pictured Rocks. Near the Porcupine Mountains and at the Montreal River, however, it has a higher dip owing to the proximity of the igneous rocks to the coast. On starting from the lake shore, at any point where the sandstone shows itself in horizontal beds, and going south towards the trap range, we find ourselves gradually rising, and the dip of the sandstone gradually increasing, so that the observer may form a pretty correct idea of his distance from the trap range by the amount of dip of the sandstone over which he is passing. The cupriferous belt itself is made up of a varying number of alternating beds of trap, conglomerate and sandstone, which latter differs from the sandstone at a distance from the trap only in being somewhat darker colored and having the quartzose grains more firmly cemented together. The number of alternations of sedimentary and igneous layers is very variable. In the Keweenaw Point district, where the igneous action seems to have been most intense, the sections across the cupriferous range show numerous beds of conglomerate and sandstone intercalated between masses of trappean rock of variable thickness.* In the Ontonagon district the number of alternations seems to be considerably less, while there is less regularity in the trappean ranges as well as in the sedimentary beds associated with them.

The beds of conglomerate are invariably found in juxtaposition with the trap, dividing this rock from the sandstone, or else separating two layers of trappean rock of different lithological character. Hence, the inference is not unreasonable that the formation of the ore is closely allied with the appearance of the other. On the north the range is usually flanked by a heavy deposit of conglomerate, while, to the south, the rock is only occasionally seen, and rarely attains any considerable thickness. The lithological character of the conglomerate indicates also the combined agency of igneous and aqueous causes in its formation. Much of it is made up of a coarse detritus or aggregate of broken and half-rounded fragments of trappean rock, showing the

* For detailed sections across the cupriferous range, see Foster and Whitney's Report, Part I.

action of sudden and violent forces, rather than of slow and long-continued ones.

The conglomerate appears to thin out rapidly as we recede from the igneous rocks, forming wedge-shape masses which gradually pass into sandstone. This fact has been actually observed in some instances, although, usually, the natural sections are not sufficiently favorable to allow the exact relation of the sedimentary to the igneous rocks to be made out. There are also patches of pebbly materials, formed exclusively by the agency of water, which occur among the sandstones, at a distance from the trap. These are of very limited extent, and are not at all comparable with the great conglomerate masses associated with the igneous rocks. They are evidently the result of local currents and the material of which they are composed is the same as that of the sandstone itself.

The dip of the series of bedded trap, conglomerate and sandstone is usually very regular, and varies from 40° to 50° along the culminating portion of the range, where it is highest. In only one locality, so far as observed, does it exceed 50°, and that is at the mouth of the Montreal River where it amounts to 80°. At this point there is a remarkable development of the conglomerate, which attain a thickness of about 1800 feet, and is overlaid by a still greater mass of dark shales and sandstones. The conglomerate rapidly thins out, both to the east and to the west, being apparently the result of the more intense action of igneous causes which took place in this portion of the range, tilting up the whole system at a higher angle than at any point on the south shore of the lake.

On the whole, we are unable, from a careful examination of numerous sections on the south shore of the lake, to see any reason for separating the cupriferous range from the sandstone which flanks it on both sides. It appears evident to us that it should be regarded as a local modification of the normal sandstone, and the result of the violent igneous action which prevailed along several parallel lines of fissure extending in a northeast and southwest direction through the Lake Superior region. It is certain that a portion, at least, of the sandstone had been deposited before the trap range assumed its present position, since there is abundant proof that the former was raised from its original position by the upheaval of the latter.

But if we were to admit that the cupriferous beds of the south shore of Lake Superior were to be classed as a system independent of the Potsdam sandstone, we can see no reason for parallelising them with those of the north shore of Lake Huron. These latter exactly resemble in lithological character the Azoic rocks of the Lake Superior survey, and are quite distinct from those of the native copper-bearing series.

The Huronian beds are chiefly made up of a compact and almost vitreous quartz-rock, in no respect resembling the sandstone of the south shore of Lake Superior, even where the latter is most hardened and metamorphosed by immediate contact with the trap. The beds of conglomerate in the Huronian series are of very subordinate importance and entirely differing in character from the great conglomerate bands associated with the igneous rocks of the south shore of Lake Superior. In the former case the base of the conglomerate is almost invariably quartz in a high state of vitrification, while the pebbles are made up of variously colored jaspers or hornstone, often blood-red, which contrast beautifully with the white quartz-rock in which they are imbedded and to which they are so firmly soldered that it is difficult to say that they may not, in some cases, be rather the result of segregating agencies within the rock, than actual pebbles imbedded in a matrix. The whole aspect of the rock is that of one having undergone a much higher degree of metamorphism than the Lower Silurian conglomerates have been subjected to.

Mr. Logan thus states the reasons for considering these formations to be of the same age. "The chief difference in the copper-bearing rocks of Lakes Huron and Superior, seem to be in the great amount of amygdaloidal trap present among the latter, and of white quartz-rock or sandstone among the former. But on the Canadian side of Lake Superior there are some considerable areas in which important masses of interstratified greenstone exist without amygdaloid, while white sandstones are present in others as on the south side of Thunder Bay, though not in the same state of vitrification as those of Huron. But notwithstanding these differences, there are such strong points of resemblance in the interstratification of the igneous rocks, and the general mineralized condition of the whole, as to render their positive or proximate equivalence highly probable, if not almost certain; and the conclusive evidence given of the age of the Huron would thus appear to settle that of the Lake Superior rocks in the position give to them by Dr. Houghton, the late State Geologist of Michigan, as beneath the lowest fossiliferous deposits, a position which, as will be seen by a reference to the Report of Progress I had the honor to submit to your Excellency in 1846, appeared to me to derive some support from evidences on the Canadian side of Lake Superior itself."*

In order to arrive at a better understanding of the matter in question, we will briefly notice some of the most important facts in the geology of the north shore of Lake Superior, where the phenomena are much more complicated and difficult to decipher

* Geol. Survey of Canada, Report on the North Shore of Lake Huron; 1849, p. 20.

than on the south side. On Isle Royale we have the exact counterpart of the principal mineral range of Keweenaw Point with the exception that the dips are in the opposite direction, being in each case towards the lake. Crossing over the channel which separates the island from the north shore of the lake, and which is from 15 to 20 miles in width, we find a great belt of trappean rock extending along the shore from Pigeon River to Fort William and rising in high cliffs. This portion of the trap is characterized by its unbedded character, is hard and crystalline, destitute of amygdules, and may be considered as the counterpart of the South or Bohemian Range of Keweenaw Point. From the west side of Thunder Bay to the east of Neepigon, the bedded trap and interstratified sandstones and conglomerates predominate. The peninsulas separating Black, from Thunder and Neepigon bays, as well as the larger islands which lie in front of these very considerable indentations in the north shore of the lake, must be referred to the same age as the rocks of Isle Royale and Keweenaw Point. There is no perceptible difference between the rocks of this portion of the north shore and those of the south side of the lake, either in lithological character or in the phenomena of the mineral veins associated with them, except that the beds of rock on the north shore being more broken up by short lines of fracture and thinner, the veins which intersect them are smaller and more irregular. The black slates of Thunder Cape are a local variation in composition of the sandstone like the dark and highly fissile beds of Montreal, Presqu' Isle, and Iron Rivers on the other side of the lake, which pass gradually into the usual red sandstone upwards and downwards. All the facts collected on the northern shore indicate a somewhat greater thickness of the interstratified igneous and detrital rocks, and a more powerful and irregular denudation than that which took place on the other side of the lake.

Underlying and uncomformable with all this great series of traps, conglomerate and sandstone, we have, as on the south shore, the azoic series, made up of talcose and hornblende slates and gneissoidal quartz-rock resting on a granitic and syenitic nucleus, which forms the high ridges to the northwest of Thunder and Black Bays, and extends into the interior to an unknown distance. The same series forms the principal portion of the eastern side of Lake Superior from the northeastern angle of Neepigon Bay down to the immediate vicinity of the St. Mary's River, the outlet of the lake. The small islands lying in front of the shore in the southeastern corner of the lake are made up of the sandstone of the lower Silurian series, a few isolated patches of this rock occurring at intervals along the shore down as far as Lake Huron.

The study of the vein phenomena of the various formations around the shores of Lake Superior seems to confirm the correctness of the views maintained above. The native copper-bearing veins are exclusively confined to the bedded trap of Lower Silurian age, and are not found in the azoic series at all. These veins are marked by peculiar gangues, in which one or more of the zeolitic minerals are rarely wanting, Prehnite and Laumonite being the most common. These minerals, however, do not form the main bulk of the vein-stone, but are mixed with a larger proportion of quartz and calc-spar. This is the case where the trap forms the wall-rock; but when the vein passes into the conglomerate, the predominating vein-stone is calc-spar. All the productive veins thus far, however, have been profitably worked in the trap alone, although large masses of copper have been occasionally met with in the conglomerate. In a few cases veins have been worked within the trap itself, which were made up almost entirely of calcareous spar; but in no instance has this been found to be a productive gangue, there being rarely more than a trace of copper mixed with it. In the unbedded trap, calc-spar and heavy spar are the predominating vein-stones, in some instances associated with crystallized quartz, but native copper does not occur in this association, the sulphuret of this metal, as also of zinc and iron, being the usual metalliferous ingredients of veins in this position. Copper pyrites is rarely found occurring in any considerable quantity in the veins of the unbedded or bedded traps associated with rocks of Silurian age. A few of the native copper veins exhibit occasional minute traces of this ore, while in the veins of the unbedded trap it is considerably more common, although never, as far as has yet been observed, predominating in quantity over the other ores, and usually falling far below them. It may be remarked, however, that the veins in this position, although frequently wide, regular and well-developed, have in no instance proved, on being worked, to contain ore enough to afford any reason to hope for their profitable exploitation; many of the best-developed ones contain hardly a trace of ore. Passing from the Lower Silurian to the Azoic System, we find an entire change in the character of the veins, both as regards their gangues and the associated ores. In every case in which mines have been wrought in rocks, which according to the views presented above, should be classed with the Azoic, quartz constitutes almost the exclusive vein-stone, while the only valuable ore occurring in sufficient quantity to be worthy of notice is copper pyrites, the native metal being never present in this association. Many of the veins in the Azoic are barren of copper ore but, contain, on the other hand, an abundance of iron pyrites; indeed the number of workable deposits of copper in this position appears to be small. Those

which afford the greatest promise of success are included in the trap which accompanies the slates and quartz-rock. The granitic and gneissoidal rocks of this period are frequently traversed by heavy vein-like masses of quartz; but their mineral contents are usually confined to iron pyrites. In the Huron Mts., however, on the south shore of the lake, near Keweenaw Bay, there are some veins which carry considerable copper pyrites and which may, eventually, be found worthy of exploration.

The number of metalliferous deposits in rocks equivalent to the native copper-bearing range of the south shore, which are known to exist upon the north shore of Lake Superior, is very great. They are especially abundant upon Isle Royale and on the numerous points and islands which lie between Thunder and Neepigon Bays. Considerable money has been expended in exploring in this region, and in attempts at mining for copper. Abundant as are the localities in this portion of the lake in which this metal has been found, it may be doubted whether there exists a single vein which can be worked with profit, and it is certain that none of those on which, up to a recent period, mining operations have been commenced, show any very encouraging indications. Valuable deposits may perhaps yet be discovered; but it appears that the thinness and irregularity of the igneous beds and the frequent changes of lithological character have prevented the metalliferous veins from assuming that development which they have in the cupriferous range of the south shore.

The character of the metalliferous deposits which occur in the Azoic rocks still farther east than Lake Huron, is similar to that which they present in the region of this lake and Lake Superior. The sulphurets of copper, lead and zinc are the chief ores, and nowhere do we find any veins resembling in character those of the native copper-bearing rocks of the bedded trap series, neither do we find in the reports of the Canada Survey any indication of the Huronian System having been recognized to the east of Lake Huron, the Laurentian, or Azoic, being everywhere in that direction succeeded by the Potsdam sandstone, just as it is on Lake Superior in point of fact.

From these considerations, it appears to us that the native copper-bearing series of the north and south shores of Lake Superior cannot be separated from the Potsdam sandstone with which it is associated, and neither is there any reason whatever for placing it in the same line with the rocks of the north shore of Lake Huron. These latter, as well as the great mass of crystalline rocks to the north and east in Canada, are identical in position and lithological character with the series described by Mr. Foster and myself under the name of the Azoic System

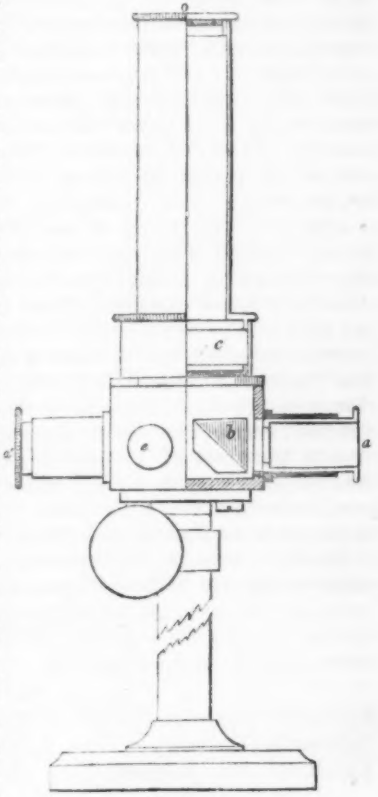
and which cover so large an extent of country in Michigan, Wisconsin, and Minnesota. These Azoic rocks were described by Mr. Logan in his various reports, previous to the one for 1852–3, under the name *metamorphic*. The term "Laurentian," proposed in that report for this series, had been previously adopted by Mr. Desor and the Geologists of the Lake Superior survey for the post-tertiary deposits, containing marine fossils, which are found in the valley of the St. Lawrence and elsewhere, and which had been called "second drift" by some geologists.* The use of the same term to designate a group or system at the other extremity of the geological scale seems likely to lead to confusion, and we hope that it will be dropped for the lower system, and retained for the deposits to which it was first applied. Strong objections may also be made to the use of the term "Cambrian," which has been applied by Messrs. Logan and Hunt, as synonymous with "Huronian," in the "Esquisse géologique du Canada," published at Paris in 1855, and which has also been used by other geologists in the United States to designate various groups low down in the series, and of doubtful age and position. The claims of the Cambrian to recognition as a distinct system, and the question how much of the Silurian it should be allowed to swallow up, have already been the cause of sufficient discussion in England and we trust that the controversy may not be imported into this country. By far the larger number of geologists have agreed in embracing all the fossiliferous rocks, down to the bottom of the series, within the Silurian series, and Prof. Sedgwick himself would agree, that to restrict the term Cambrian to the unfossiliferous portion of the groups to which he gives that name, would be not at all in accordance with his views, and more objectionable than to do away with it altogether. If we find in this country a series of fossiliferous beds below those at present recognized, and whose organic contents cannot be considered as being of Lower Silurian type, let us give them a new name, which shall not involve us in any Cambrian controversies; but, if, as appears from the evidence thus far collected, we have reached in the lower sandstones of the northwest the downward limit of organized existence, we are justified, for the present at least, in the use of the term Azoic to designate the rocks upon which these sandstones rest unconformably.

* See Bull. Geol. Soc. [2], viii, 422.

ART. XXXII.—*Notice of a Photometer and of some experiments therewith upon the comparative power of several artificial means of Illumination;* by B. SILLIMAN, Jr., and CHAS. H. PORTER.

THE photometers in general use for determining the comparative illuminating power of various sources of light, depend upon a comparison either of shadows or of illuminated discs. Rumford's well known instrument is of the former description, and Ritchie's is an example of the latter. Having found much difficulty in the adaptation of any of the instruments commonly in use to the accurate admeasurement of the illuminating power of various forms of gas jets, Prof. B. Silliman, Jr. was led to consult Messrs. J. & W. Grunow of New Haven, opticians of eminent merit, and requested them to give form to our mutual conclusions by constructing the instrument here described.

1.

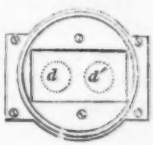


[Scale ½]

Description of the instrument.—In this instrument the pencils of light are received through diaphragms of exactly equal magnitude, fig. 1, *a a'*, upon two equal triangular prisms of flint glass placed at the angle of total reflection. The opening is situated at the bottom of the draw tube, and may be varied in form or position at pleasure. The position of one of these prisms may be seen at *b*, showing one-half of the instrument in vertical section. The two illuminated discs are received upon a diaphragm of ground glass placed in a dark chamber *c*, 30 m.m. in diameter. Figure 2 shows the diaphragm in plan with the two discs *d d'* in relative position. Above this is the eye-piece *o*, and draw tube fitted with diaphragms of various apertures and of differently tinted glass. The whole instrument is

mounted upon a sliding stand to allow of adjustment at different elevations. For convenient adjustment of the prisms at the angle of total reflection a slight motion of rotation is provided by the knerled heads *e*, fig. 1. The edges of the illuminated discs are brought near to each other, but should not overlap. The carriage upon which the instrument stands slides upon a graduated bar 150 inches long, and the readings are made with a vernier from a zero mark. The two lights to be compared are of course at the two extremities of the graduated bar and remain fixed at the same elevation. The photometer is then moved until an equality of illumination is seen in the two discs in the dark chamber. A yellowish green eye-glass has been found to be the most perfect compensation for differences of color produced by different lights. The facility of use and the accuracy of this instrument exceeded our best expectations. Persons wholly unacquainted with such observations readily appreciated very slight differences of illumination in the two discs, and where the instrument was purposely placed out of its proper position, such persons succeeded in the first attempt in bringing it surprisingly near its accurate adjustment. The eye readily detected a difference of one-fourth of an inch in the position of the instrument by the change in the brilliancy of the two discs. This quantity is equivalent to $\frac{3\,9}{1\,0\,0}$ths of one per cent of the whole quantity. Some scientific uses may demand a greater degree of accuracy than this, but it is quite equal to the demands of the arts. The use of a colored eye-glass of the proper tint to compensate the red rays of the more feeble source of illumination and to allow the passage of the yellow rays is quite indispensable to accuracy. The photometer most resembling this is Ritchie's, but the superior accuracy and neatness of the instrument here described is very obvious. The dark chamber and compensating eye-piece give to the discs of light upon the ground glass diaphragm, a facility of compensation and of adjustment hardly inferior to the accuracy attainable by Babinet's polarizing photometer, to which there are some objections needless to be dwelt on here.

2.



Experiments with the instrument.—The following trials were made in the city of New Haven on the last evenings of January 1856, during very severe weather, upon two samples of coal gas. On the 1st and 5th evenings the coals used in charging the retorts consisted of a mixture of

	1st.	5th.
Fairmount (Maryland),	5,725 lbs.	5,642 lbs.
Newcastle (English),	5,725 "	5,641 "
Hillsboro' (New Brunswick),	750 "	750 "
	12,200 "	+ 12,033 " = 24,233 lbs.

There were produced from this mixture 102,724 cubic feet of gas or 4·24 cubic ft. to the pound of coal, and 40 bush. coke, weighing 39 lbs. to the bush. =1540 lbs. from 2000 lbs. coal.

On the 2nd, 3rd and 4th nights the "Ohio Diamond Coal" (Big Yellow Creek, O.), was used to the amount of 38,500 lbs. In the three days, there were produced 135,110 cubic feet of gas or 3·50 cubic feet to the pound of coal, and 30 bushels of coke weighing 41·5 lbs. per bush. =1245 lbs. from 2000 lbs. coal.

In order to avoid as far as practicable the errors likely to arise from the condensation of the more highly illuminating portions of the gas by the cold, and from other sources, the trials were made on the three first evenings at the gas-house, where the gas was obtained directly from the mains, before it had been refrigerated by distribution. On the fourth and fifth evenings the trials were made in the city, nearly three-fourths of a mile from the works. The contrast between the two sets of experiments is most striking, particularly on the last evening, as compared with the first, as on both these occasions it was the gas of ordinary supply which was used.

The standard of comparison or unit in these trials was a "Judd's patent sperm candle, No. 6," burning 127 grains in the hour. This was burned in a sheathed candlestick and by aid of a spring, (like a coach candle lamp,) was kept always at the same elevation. Observations were also made with the Carcel's mechanical lamp as a unit. The size of lamp employed was one inch diameter of wick, burning 796 grains per hour of the first quality winter-strained sperm oil, such as is used by the government light-houses in lamps of similar construction. This form of lamp is regarded as furnishing the most uniform light of any artificial source for a series of hours. In the following tables (see next page) the results are presented in as simple and condensed a form as practicable. The several burners compared are those most commonly used in the United States; the same set of burners was used in all the trials. The gas consumed was registered by a small registration meter, on the dial of which an index notes the cubic feet and fractions consumed per hour. As the same instrument was used throughout, no errors of importance can have arisen as between the several sets of observations. The meter was not compared with any absolute standard, nor was the density of the gas determined.

BURNERS.	I. "Fairmount," &c. at Gas Works. Pressure 2·40 in.			II. "Diamond," at Gas Works. Pressure 2·60 in.			III. "Diamond," at Gas Works. Pressure 2·40 in.			IV. "Diamond," at Marschal & Stratton's.			V. "Fairmount," &c. Marschal & Stratton's.			Average consumption per hour, in cubic feet.	Average cost per hour, in cents.	Light produced when burning average am't = to — candles.	Cost of light = to Carcel Lamp, per hour.
	Cubic feet consumed per hour.	Equal to — candles.	Burner consuming 5 ft. = to — candles.	Cubic feet consumed per hour.	Equal to — candles.	Burner consuming 5 ft. = to — candles.	Cubic feet consumed per hour.	Equal to — candles.	Burner consuming 5 ft. = to — candles.	Cubic feet consumed per hour.	Equal to — candles.	Burner consuming 5 ft. = to — candles.	Cubic feet consumed per hour.	Equal to — candles.	Burner consuming 5 ft. = to — candles.				
Union jet, (Scotch burner,)	19·59	4·9	19·58	4·3	20·80	24·18	4·8	21·77	22·67	5·2	22·95	22·07	5·1	16·18	15·86	4·86	1·944	20·25	·96
Cornelius' fish-tail, ...	14·39	5·	14·39	4·3	20·80	24·18	5·0	22·78	22·78	5·0	18·51	18·51	5·	13·35	15·35	4·86	1·944	17·96	1·082
Soule's flat top bat-wing, ..	13·74	4·	17·17	4·3	15·48	18·00	4·0	15·49	19·36	4·1	12·41	15·13	4·	12·92*	9·45	4·08	1·632	13·83	1·180
Münsig's single cut bat-wing,	9·82	4·5	10·91	4·	13·22	16·52	5·2	16·13	150·5	4·6	12·76	13·86	4·6	8·71	9·46	4·58	1·832	12·13	1·510
Batten's double cut bat-wing,	10·18	4·	12·73	3·5	13·22	18·88	3·3	9·48	14·36	3·6	9·87	13·70	3·	6·61	11·02	3·48	1·392	9·87	1·413
Stratton's Argand, ...	27·40	7·	19·6	6·0	28·88	24·07	7·0	23·86	17·04	6·67	24·02	18·00	7·	23·98*	12·98	6·73	2·692	25·67	1·049
Homan's double jet, ...	....	...	.....	5·75	31·94	27·77	5·0	26·21	26·21	6·0	20·73	17·28	6·	18·98	15·82	5·69	2·276	24·46	·926
		grs.														grains			
Judd's patent sperm candle,	....	127	.....	.....	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....	127·	1·001	.....	10·01
Carcel Lamp, ...	10·	796	.....	.....	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....	796·	3·149	.....	3·149

* Calculated.

ART. XXXIII.—*Researches on the Ammonia-cobalt Bases;* by WOLCOTT GIBBS and F. A. GENTH. Part I.

Continued from page 265.

CHLORPLATINATE OF PURPUREOCOBALT.

WHEN a solution of bichlorid of platinum is added to one of the chlorid of Purpureocobalt, a brown-red precipitate is thrown down, which is a combination of the two chlorids. When dried it has a fine rich brown-red color and high lustre. The crystals seen under the microscope are usually aggregations of flat pale reddish-brown needles. They are very distinctly dichrous, the ordinary image being pale violet-rose, while the extraordinary image is rich orange-red.

The chlorplatinate is nearly insoluble in cold, and with great difficulty soluble in hot water. It resists the action of reducing agents much more powerfully than the chlorplatinates of the alkaline metals. Thus it must be boiled for a very long time with zinc and chlorhydric acid before a complete reduction of the platinum is effected. If the process be interrupted before the reduction is complete, brilliant yellow granular crystals are often formed in the liquid. We have not determined the constitution of these crystals, but they are not chlorplatinate of ammonium. Sulphurous acid reduces this double chlorid readily, and yields a red solution containing the protochlorids of platinum and of cobalt. We may here remark, that so far as our observation has hitherto extended, the action of a reducing agent upon any constituent of a compound containing an ammonia-cobalt base extends invariably to the ammonia-cobalt base itself.

The chlorplatinate of Purpureocobalt has the formula

$$5NH_3.Co_2Cl_3+2PtCl_2$$

as the following analyses show:

0·6765 grs. (reduced by boiling with SO_2 and the platinum precipitated as sulphid by $NaO.S_2O_2$ after adding HCl) gave 0·2267 grs. of platinum = 33·51 per cent.

0·9521 grs. gave 0·3169 grs. of platinum and 0·2483 grs. sulphate of cobalt = 9·93 per cent cobalt.

—— grs. gave —— grs. of chlorid of silver = 41·80 per cent chlorine.

The formula requires

	Eqs.	Calculated.	Found.
Cobalt, - -	2	10·10	9·93
Platinum, - -	2	33·50	33·51
Chlorine, - -	7	42·01	41·80

This salt is identical with the chlorplatinate described and analyzed by Claudet, and for which that chemist found the same

formula, with the exception of the hydrogen, which he makes 16 in place of 15 equivalents. We have also obtained it from a chlorid which gave the reactions of chlorid of Roseocobalt, but we must leave it for the present undecided whether in this case there was a conversion of Roseocobalt into the isomeric Purpureocobalt, by the action of the chlorid of platinum, or whether the chlorid of Roseocobalt had already undergone the change. We consider it certain that the salt in question is a salt of Purpureocobalt, because it contains *two* in place of *three* equivalents of bichlorid of platinum. We shall show further on, that the oxygen salts of this base contain either *two* or *four* equivalents of acid, and it is well known that in the chlorplatinates there is—we believe invariably—but one equivalent of bichlorid of platinum for each equivalent of chlorine in the chlorid with which it is united. Since there are three equivalents of chlorine in this chlorid of Purpureocobalt, we infer that two of them are differently combined from the other two, so that the rational formula of the chlorplatinate is

$$5NH_3.Co_2Cl.Cl_2+2PtCl_2.$$

We shall develop this view more fully when speaking of the oxygen salts of Purpureocobalt.

OXALATE OF PURPUREOCOBALT.

This most beautiful salt is readily prepared by adding a solution of oxalate of ammonia to one of chlorid of Purpureocobalt. After a short time violet-red needles are thrown down, which may be washed with cold water. As thus prepared, the salt is almost chemically pure. The color of the oxalate of Purpureocobalt is the violet $\frac{6}{10}$ of the first circle of Chevreul's scale; the crystals are not sensibly dichrous. We have not, as yet, obtained measurable crystals of this salt. Under the microscope four- and six-sided acicular prisms are distinguishable, but without characterizing terminal planes.

The oxalate of Purpureocobalt has the formula

$$5NH_3.Co_2O_3,\ 2C_2O_3+3HO$$

as the following analyses show:

0·2723 grs. gave 0·1574 grs. sulphate of cobalt = 22·00 per cent of cobalt.
0·3545 grs. gave 0·2045 grs. " " = 21·95 " "
0·8970 grs. burnt with oxyd of copper gave 0·2973 grs. carbonic acid = 27·11 per cent of oxalic acid.

The formula requires

	Eqs.	Calculated.	Found.	
Cobalt, - -	2	22·09	22·00	21·95
Oxalic acid, - -	2	26·96	27·11	—

The oxalate is nearly insoluble in cold water, and not very soluble in boiling water, even after addition of free oxalic acid. The salt does not crystallize well from its solutions, and we have always obtained it in the most beautiful form by direct precipitation from the chlorid. The salt is neutral to test paper, and is the only neutral oxysalt of Purpureocobalt which we have yet obtained. It will appear from what follows, extremely probable that there is an acid oxalate of Purpureocobalt containing four equivalents of oxalic acid. We have not obtained such a salt however, in one or two experiments made for the purpose.

ACID SULPHATE OF PURPUREOCOBALT.

Our efforts to obtain a neutral sulphate of Purpureocobalt containing two equivalents only of sulphuric acid have hitherto been fruitless. When a solution of chlorid of Purpureocobalt is treated with sulphate of silver, chlorid of silver is formed, and the red supernatant liquid yields, on evaporation, crystals of sulphate of Roseocobalt. Precisely the same result is obtained with the chlorid and nitrate of silver; the red solution yielding crystals of nitrate of Roseocobalt. We consider it probable that in these cases the sulphate and nitrate of Purpureocobalt, $5NH_3.Co_2O_3, 2SO_3$, and $5NH_3.Co_2O_3, 2NO_5$, are really formed by double decomposition, but that during evaporation the equivalent of free sulphuric or nitric acid formed at the same time with the sulphate or nitrate, reacts upon this so as to convert it into a salt of Roseocobalt with three equivalents of acid. In equations we should have for the sulphate

$$5NH_3.Co_2Cl_3+3AgO, SO_3+HO=5NH_3.CO_2O_3, 2SO_3+HO, SO_3+3AgCl.$$

$$5NH_3.Co_2O_3, 2SO_3+HO, SO_3=5NH_3.Co_2O_3, 3SO_3+HO.$$

When oil of vitriol is poured upon chlorid of Purpureocobalt in quantity sufficient to make a thick paste, the mass assumes a fine purple color, and swells up very much at first, so that a large vessel is necessary. If the solution, after the evolution of chlorhydric acid has ceased, be diluted with about twice its volume of water, and allowed to stand for a few hours, a large mass of beautiful violet-red needles is deposited. The mother liquor, after standing for a longer time, deposits more crystals. These crystals are to be quickly washed with a little cold water, drained and dried by pressure between folds of bibulous paper. They are usually free from chlorine, and are very nearly pure acid sulphate of Purpureocobalt. The mother liquor contains more of the acid sulphate together with small quantities of another sulphate which we shall describe more fully hereafter, and frequently a little undecomposed chlorid. By boiling this mixture

with chlorhydric acid chlorid of Purpureocobalt is formed, which may be employed in preparing a fresh portion of the acid sulphate.

The acid sulphate of Purpureocobalt may also be prepared by the action of strong sulphuric acid upon the sulphate of Roseocobalt. For this purpose oil of vitriol is to be poured upon the sulphate in quantity sufficient to produce an oily liquid on heating in a water bath. The digestion is to be continued for one or two hours, according to the quantity of salt employed, care being taken that no oxygen is evolved. The dark purple liquid is to be suffered to cool, diluted with an equal bulk of water, and allowed to crystallize.

The acid sulphate as thus obtained is difficult to purify. By dissolving it in a small quantity of hot water, and evaporating it quickly, fine crystals may sometimes be obtained. When, however, the solution is evaporated slowly in the air, crystals of sulphate of Roseocobalt are formed in abundance, while the mother liquor contains free sulphuric acid. When a solution of the acid sulphate is neutralized with ammonia, and allowed to crystallize by slow evaporation, the sulphate of Roseocobalt is also obtained, but by rapid evaporation dark-red, prismatic crystals are sometimes formed, which we have not yet obtained in sufficient quantity for a complete analysis. They may prove to be the neutral sulphate of Purpureocobalt.

The acid sulphate of Purpureocobalt crystallizes in fine, red, prismatic crystals, which, according to Prof. Dana, belong to the trimetric system, and are hemihedral. The observed forms are I, $i\breve{\imath}$, $\frac{1}{2}\breve{\imath}$, $\cdot\frac{1}{2}\bar{\imath}$, $i\bar{\imath}$ (?) or in other symbols ∞, $\infty\text{-}\bar{\infty}$, $\frac{1}{2}\text{-}\breve{\infty}$, $\cdot\frac{1}{2}\text{-}\bar{\infty}$, $\infty\text{-}2$ (?):

$I : I = 106°$.

$I : \breve{\imath} = 127°$ (126° 50′—127° 10′)

$\frac{1}{2}\breve{\imath} : \frac{1}{2}\breve{\imath} = 122°\ 42'$.

$1\bar{2} : 1\bar{2} = 67°\ 54'$.

$a : b : c = 1{\cdot}0927 : 1 : 1{\cdot}3271$.

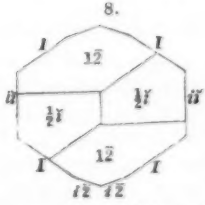


Fig. 8 represents an end view of a crystal of this salt; $1\bar{2}$ is hemihedral and $i\bar{2}$ usually so; the symbol $i2$ is probably correct, though the observed angle varies much.

The acid sulphate is very soluble in water, and has a distinct though not strongly acid taste. It reddens litmus, and expels carbonic acid from the carbonates.

The formula of this salt is

$$5NH_3.Co_2O_3, 4SO_3+5HO$$

as the following analyses show:

0·620 grs. gave 0·2577 grs. sulphate of cobalt = 15·82 per cent cobalt.
1·1402 grs. gave 0·4756 grs. " " = 15·86 " "
1·5317 grs. gave 1·9270 grs. sulphate of baryta = 43·19 " sulphuric acid.
1·5843 grs. gave 0·7570 grs. water = 5·31 per cent hydrogen.
1·1869 grs. gave 189·5 c. c. nitrogen at 15° C. and 775^{mm}·2 (at 15°·3) = 179·6 c. c. at 0° and 760^{mm} = 19·00 per cent nitrogen.

The formula requires

	Eqs.	Calculated.	Found.	
Cobalt, - -	2	15·81	15·82	15·86
Sulphuric acid, -	2	42·89	43·19	
Hydrogen, -	20	5·36	5·31	
Nitrogen, - -	5	18·76	19·00	

The acid sulphate gives no precipitate with 3KCy, Co_2Cy_3, but only a fine red liquid, which, on evaporation, yields a red mass. Boiled with chlorhydric acid the sulphate yields the chlorid of Purpureocobalt, easily recognized by oxalate of ammonia, with which, however, the acid sulphate itself gives no precipitate. When precipitated with nitrate of baryta the acid sulphate yields a red liquid which probably contains a nitrate of Purpureocobalt, but which on evaporation gives crystals of nitrate of Roseocobalt. It is well worthy of notice, that this red liquid contains a large quantity of sulphate of baryta in solution, which it deposits during evaporation.

The products of the decomposition of the acid sulphate are similar to those of the other salts of Purpureocobalt. A rapid current of NO_x passed into the solution gives, after a short time, an abundant precipitate of the nitrate of Xanthocobalt.

The constitution of the acid sulphate might be represented by either of the following formulæ, besides that already given:

$$5NH_3.Co_2O_3,\ 3SO_3+HO,\ SO_3+4HO.$$
$$5NH_3.Co_2O_3,\ 2SO_3+2HO,\ SO_3+3HO.$$

We reject the first of these formulæ because Purpureocobalt is a biacid and not a triacid base. The second formula appears to us less probable than that which we have adopted, in the first place, because a salt so constituted ought to be strongly acid, and in the second place, because we shall presently show that there exists an oxalo-sulphate of Purpureocobalt, in which *two* equivalents of sulphuric are replaced by *two* of oxalic acid, and another and neutral oxalo-sulphate in which one equivalent of oxalic acid replaces one equivalent of sulphuric acid.

ACID OXALO-SULPHATE OF PURPUREOCOBALT.

When sulphate of Roseocobalt is boiled for several hours with an excess of a solution of oxalic acid, a clear red solution is formed, which on evaporation deposits an abundance of crystals of a bright brick-red color, and indistinct acicular form. These crystals are soluble in hot water without decomposition, and may

be purified, though with difficulty, by recrystallization. Their constitution is represented by the formula

$$5NH_3.Co_2O_3,\ 2SO_3,\ 2C_2O_3+3HO$$

as appears from the following analyses:

0·7433 grs. gave 0·3315 grs. sulphate of cobalt = 16·97 per cent cobalt.
1·3912 grs. gave 0·9535 grs. sulphate of baryta = 23·50 " sulphuric acid.
1·6895 grs. gave 1·1564 grs. " " = 23·49 " sulphuric acid.
2·7702 grs. gave 0·7070 grs. carbonic acid = 20·88 " oxalic acid.
2·0198 grs. gave 340 c. c. of nitrogen at 14°·5 C. and 763^{mm}·01 (at 15° C.)=318·1 c. c. at 0° and 760^{mm} = 19·78 per cent nitrogen.

The formula requires

	Eqs.	Calculated.	Found.	
Cobalt, - -	2	17·00	16·97	
Sulphuric acid, -	2	23·05	23·49	23·50
Oxalic acid, -	2	20·74	20·88	
Nitrogen, - -	5	20·17	19·78	

The reactions of this remarkable salt resemble closely those of the acid sulphate. It has an acid taste and reaction, gives no precipitate with oxalate of ammonia, or cobaltidcyanid of potassium, and yields chlorid of Purpureocobalt by boiling with an excess of chlorhydric acid. The formula of this salt may be written in various ways. In the first place, we may consider it as a double salt represented by the formula

$$5NH_3.Co_2O_3,\ 4SO_3+5NH_3.Co_2O_3,\ 4C_2O_3+6HO.$$

The advantage of simplicity is evidently in favor of the formula we have adopted. We may also consider it as represented by

$$5NH_3.Co_2O_3,\ 2SO_3+2C_2O_3,\ HO+HO.$$

In this case the salt should have a strongly acid taste which it has not. On the whole the formula

$$5NH_3.Co_2O_3\left\{\begin{matrix}2SO_3\\2C_2O_3\end{matrix}\right.+3HO$$

appears to deserve the preference.

NEUTRAL OXALO-SULPHATE OF PURPUREOCOBALT.

When ammonia is added to a solution of the acid oxalo-sulphate just described, a fine violet-red color is produced, and if no more ammonia be added than is sufficient to completely neutralize the acid reaction, the liquid yields, on evaporation, beautiful red prismatic crystals of a neutral salt. The neutral oxalo-sulphate is much less soluble in water than the acid salt, and has a purely saline taste: it is easily decomposed by boiling. The formation of this salt is represented by the equation

$$5NH_3.Co_2O_3,\ 2SO_3,\ 2C_2O_3+2NH_4O=5NH_3.Co_2O_3,\ SO_3,\ C_2O_3+NH_4O,\ SO_3+NH_4O,\ C_2O_3.$$

The fact that the ammonia unites with both sulphuric and oxalic acid, and not simply with *two* equivalents of oxalic acid, throws much light on the constitution of the acid oxalo-sulphate, and shows, we think, clearly that the formula of this salt cannot be

$$5NH_3.Co_2O_3, 2SO_3+2C_2O_3, HO+HO.$$

The constitution of the neutral oxalo-sulphate is represented by the formula

$$5NH_3.Co_2O_3, \begin{cases} SO_3 \\ C_2O_3 \end{cases} +7HO$$

as appears from the following analyses:

0·6367 grs. gave 0·3217 grs. sulphate of cobalt = 19·23 per cent cobalt.
0·6721 grs. gave 0·2569 grs. sulphate of baryta = 13·12 " sulphuric acid.
0·9760 grs. gave 191 c.c. nitrogen at 17°·25 C. and 767^{mm}·58 (at 17°·8) = 177·43 c.c. at 0° and 760^{mm} = 22·83 per cent.

The formula requires

	Eqs.	Calculated.	Found.
Cobalt, - - -	2	19·21	19·23
Sulphuric acid, - -	1	13·02	13·12
Oxalic acid, - -	1	11·72	
Nitrogen, - - -	5	22·80	22·83

We may further remark that the character of the action of ammonia upon the acid oxalo-sulphate leads us to hope that the neutral sulphate of Purpureocobalt may be obtained by the action of this agent upon the acid sulphate, and that in fact, this is the salt already mentioned as so obtained, but not yet analyzed. The two oxalo-sulphates described constitute, we believe, the types of an entirely new class of salts, and lead to the idea that sulphuric and oxalic acids may possibly be capable of replacing each other in combinations.

OXYD OF PURPUREOCOBALT.

The oxyd of Purpureocobalt, like that of Roseocobalt, appears to exist only in solution. It may be prepared, either by decomposing the acid sulphate by baryta water, or by digesting a solution of the chlorid with oxyd of silver in the cold. The solution is not pure in either case, containing either sulphate of baryta or chlorid of silver in solution. The oxyd, as thus prepared in solution, forms a violet-red liquid, which absorbs carbonic acid readily from the air, and which is decomposed by concentration.

The constitution of the oxygen salts of Purpureocobalt, which we have described, as well as that of the chlorplatinate of this radical, appears to us to leave no reasonable doubt that the oxyd is essentially *biacid*. According to the rule that the number of equivalents of acid in a salt is equal to the number of equivalents of oxygen in the base, the rational constitution of the oxyd of Purpureocobalt will be expressed by the formula

$$5NH_3.Co_2O.O_2.$$

We shall develop this view more fully when occupied with the purely theoretical portion of the subject, and in the second part of our memoir we shall endeavor, by the analysis and description of other salts of Purpureocobalt, to throw more light upon the nature of this remarkable radical. The chromates, pyrophosphates, and picrate of Purpureocobalt have, in particular, occupied our attention.

We have mentioned, in speaking of the reactions of chlorid of Purpureocobalt, that both the cobaltidcyanid and the ferridcyanid of potassium give precipitates in its solution. The constitution, crystalline form and physical appearance of these two precipitates exactly agree with those of the cobaltidcyanid and ferridcyanid of Roseocobalt, and we have, therefore, not hesitated to identify them with these last. We believe that in this case there is a conversion of Purpureocobalt into Roseocobalt, since in the salts in question there are three equivalents of cyanogen in the electropositive for three in the electronegative cyanid, the formulæ being as mentioned above

$$5NH_3.Co_2Cy_3+Co_2Cy_3+3HO, \text{ and } 5NH_3.Co_2Cy_3+Fe_2Cy_3+3HO.$$

As Purpureocobalt is certainly biacid, its cobaltidcyanid and ferridcyanid should have the formulæ

$$3(5NH_3.Co_2Cy_3)+2Co_2Cy_3, \text{ and } 3(5NH_3.Co_2Cy_3)+2Fe_2Cy_3,$$

although the frequent occurrence of basic double cyanids may render this point less clear than the others which also involve the biacid character of the radical.

LUTEOCOBALT.

The salts of Luteocobalt have a yellow or brown-yellow color, and are almost always well crystallized. They are in general more soluble in water than the corresponding salts of Roseocobalt; the solutions have a brown-yellow color. The salts of Luteocobalt are very stable in the presence of acids in general, but are decomposed by long heating with sulphuric acid. The neutral and alkaline solutions are readily decomposed by boiling, like the salts of the other cobalt bases. Nearly all of them have a purely saline taste. When hydrated, these salts generally effloresce in dry air or in vacuo, and become opaque, with a peculiar porcelain-like lustre and reddish-buff color. The salts of Luteocobalt may be formed, like those of the other bases described, by direct oxydation: it is well worthy of notice, however, that they are often found among the products of the decomposition of the salts of Roseocobalt and Purpureocobalt. This is especially remarkable, because the constitution of Roseocobalt is simpler than that of Luteocobalt, the former base being $5NH_3.Co_2O_3$, while the latter is $6NH_3.Co_2O_3$. We have here a singular inversion of the usual law, that the products of the

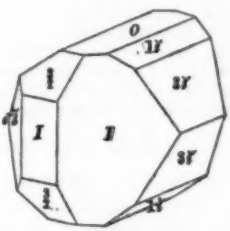
decomposition of a complex molecule are more simple in constitution than the body decomposed.

Luteocobalt, like Roseocobalt, is a triacid base.

CHLORID OF LUTEOCOBALT.

When an ammoniacal solution of chlorid of cobalt, to which a large quantity of coarsely powdered chlorid of ammonium has been added, is exposed to the air for some days, it often happens that no traces of chlorid of Roseocobalt or Purpureocobalt are found, but the bottom of the vessel becomes covered with orange-yellow crystals, which are the chlorid of Luteocobalt. Chlorhydric acid precipitates an additional quantity of the salt from the supernatant liquid. The raw chlorid, as thus obtained, is easily purified by solution in hot water, filtration, and repeated crystallization. This method of preparing the salt is by no means always successful, and very frequently results only in the formation of chlorid of Roseocobalt and Purpureocobalt, with scarcely a trace of the chlorid of Luteocobalt. We have, however, almost invariably succeeded in preparing, by this process, a mixture of the sulphate and chlorid of Luteocobalt, by employing a solution containing both the chlorid and sulphate of cobalt. The sulphato-chlorid resulting, by boiling with chlorhydric acid and chlorid of barium, yields a solution from which the pure chlorid may be obtained by repeated crystallization. The chlorid of Luteocobalt crystallizes by slow evaporation, in remarkably beautiful brownish-orange colored crystals, which belong to the trimetric or right rhombic system, and which are isomorphous with the sulphate of Luteocobalt. According to Prof. Dana, the usual forms are, in his modification of Naumann's notation, O, ∞, $\frac{3}{2}$, $\frac{\infty - 3}{2}$, $1\text{-}\breve{\infty}$, $3\text{-}\breve{\infty}$, with the angle $I : I = 113°\ 16'$. Fig. 9 represents a crystal of this salt with Dana's notation for the faces:

9.



$I : I = 113°\ 16'$.
$O : 1\breve{I} = 145°\ 55'$.
$O : 3\breve{I} = 116°\ 13'$.
$1\breve{I} : 1\breve{I} = 112°\ 2'$ (over O)
$3\breve{I} : 3\breve{I} = 52°\ 26'$ (over O)
$3\breve{I} : 3\breve{I} = 127°\ 34'$ (adjacent)
$O : \frac{3}{2} = 118°\ 35'$ (by observation)

Frémy states that this salt crystallizes in regular octahedrons; in this case it must be dimorphous, but we have never observed any forms belonging to the regular system.

The chlorid of Luteocobalt is readily soluble in boiling water, and crystallizes in a great measure from the solution on cooling. Chlorhydric acid and alkaline chlorids precipitate it unchanged. When boiled with sulphuric acid, the salt gives off abundance of chlorhydric acid gas, but it is difficult to drive off all the acid without decomposing a portion of the resulting sulphate. The salt is slowly decomposed by boiling ammonia, chlorid of ammonium, and a dark-brown oxyd of cobalt being the only products of the decomposition which we have been able to detect. Reducing agents in general act upon this salt as upon chlorid of Roseocobalt and Purpureocobalt. We have not yet, however, been able to obtain with the chlorid of Luteocobalt compounds analogous to those which are produced by the action of sulphurous acid and deutoxyd of nitrogen upon the chlorids of Roseocobalt and Purpureocobalt, although we have repeatedly made the attempt.

The chlorid of Luteocobalt is dichrous. In the dichroscopic lens the ordinary image is pale violet, while the extraordinary image is orange-violet. The color of the salt, in coarse powder, approaches the orange-yellow of the first circle, but the color of the mass of crystals could not be defined by the chromatic scale, which we employed. Chlorid of Luteocobalt exhibits a remarkable tendency to form chloro-salts with metallic chlorids. These salts are formed with great ease, by the direct union of the two chlorids, and are worthy of notice for their stability and capacity of crystallization. Of these salts, which are very numerous, we have examined only the compounds with gold and platinum.

The analyses of chlorid of Luteocobalt lead to the formula

$$6NH_3.Co_2Cl_3,$$

0·2036 grs. gave 0·1180 grs. of sulphate of cobalt = 22·05 per cent cobalt.
0·3350 grs. gave 0·1938 grs. " " = 22·01 " "
0·5110 grs. gave 0·2970 grs. " " = 22·11 " "
0·3335 grs. gave 0·1930 grs. " " = 22·02 " "
0·2942 grs. gave 0·4723 grs. chlorid of silver = 39·67 per cent chlorine.
0·4886 grs. gave 0·7846 grs. " " = 39·78 " "
0·3902 grs. gave 0·2346 grs. water = 6·68 per cent hydrogen.
0·4617 grs. gave 0·2800 grs. " = 6·73 " "
0·7305 grs. gave 200·5 c. c. of nitrogen at 21°·5 C. and 765^{mm}·80 (t = 22°·2 C.) = 182·3 c. c. at 0° and 760^{mm} = 31·34 per cent nitrogen.
0·7773 grs. gave 212 c. c. of nitrogen at 18° C. and 762^{mm}·75 (t = 18°·6 C.) = 194·94 c. c. at 0° and 760^{mm} = 31·49 per cent nitrogen.

Comparing these with the calculated results, we have

	Eqs.		Theory.	Mean.		Found.		
Cobalt,	2	59·0	22·06	22·05	22·05	22·01	22·11	22·02
Chlorine,	3	106·5	39·79	39·73	39·68	39·78	——	——
Hydrogen,	18	18·0	6.73	6·70	6·68	6·73	——	——
Nitrogen,	6	84·0	31·42	31·41	31·49	31·34	——	——
		267·5	100·00	99·89				

The formula $6NH_3.Co_2Cl_3$ is given, by both Frémy and Rogojski, and no reasonable doubt can be entertained of its accuracy. The density of the chlorid of Luteocobalt, as taken in alcohol, is 1·7016 at 20° C., its atomic volume is consequently 157·2.

The reactions of the chlorid of Luteocobalt are as follows:

Iodid of potassium gives a bright yellow precipitate.

Bromid of potassium gives a less brilliant yellow precipitate.

Ferrocyanid of potassium gives a chamois colored precipitate, which becomes black on boiling.

Ferridcyanid of potassium gives beautiful yellow needles, which are nearly insoluble.

Cobaltidcyanid of potassium gives a pale fawn colored precipitate of fine needles.

Terchlorid of gold gives bright yellow granular crystals of the chloraurate.

Bichlorid of platinum gives yellow or orange-yellow needles of the chlorplatinate.

Chromate of potash gives a bright yellow precipitate of the chromate.

Oxalate of ammonia gives a buff yellow precipitate, soluble in oxalic acid.

Tribasic phosphate of soda gives, after a short time, a yellow precipitate.

Pyrophosphate of soda gives a pale buff colored precipitate.

Picrate of ammonia gives a beautiful yellow precipitate of very fine silky needles.

Alkalies and their carbonates produce no precipitate in the cold.

Sulphid of ammonium gives a black precipitate.

CHLORPLATINATE OF LUTEOCOBALT.

Chlorid of platinum produces, immediately, in a solution of the chlorid of Luteocobalt, a beautiful orange or yellow precipitate of the chlorplatinate. When the solutions employed are concentrated, the precipitate is orange colored; when the solutions are dilute, yellow needles are thrown down. The difference is here only in the quantity of water of crystallization, and the orange granular crystals may be converted into the pale yellow needles by solution in a large quantity of hot water and recrystallization.

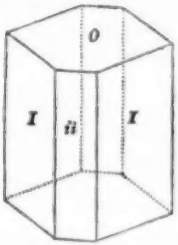
According to Prof. Dana's measurements, the acicular crystals belong to the monoclinic system, so far as it is possible to determine. The crystals are usually hollow and much striated longitudinally. The observed forms are *I*, *ii*, and *O*, and the angles

10.

$I : I = 107° 10'$.

$I : ii = 143° 50'$.

$O : ii = 114° 15'$.



Twin crystals are frequent, the composition being parallel to the plane *O*. The salt is very slightly soluble in cold water, but dissolves in much boiling water, from which it separates on cooling. When gently heated in a porcelain crucible it gives off ammonia and chlorid of ammonium, and becomes green. The green mass, on solution in water, gives globular aggregations of minute crystals of a buff color, which may be a new salt, but which we have not specially examined. Zinc decomposes the chlorplatinate of Luteocobalt only by very long boiling in an acid solution, metallic platinum being separated as a black powder, while chlorids of cobalt and ammonium are formed.

The formula of the orange salt is

$$6NH_3 . Co_2Cl_3 + 3PtCl_2 + 6HO$$

as the following analyses show:

1·220 grs. gave 0·4321 grs. metallic platinum = 35·41 per cent.
1·220 grs. gave 0·2261 grs. sulphate of cobalt = 7·05 per cent cobalt.

	Eqs.	Calculated.	Found.
Cobalt, - -	2	7·10	7·05
Platinum, - -	2	35·64	35·41

The formula of the yellow salt is

$$6NH_3 . Co_2Cl_3 + 3PtCl_2 + 21HO$$

as appears from the analyses:

0·2638 grs. gave 0·0822 grs. metallic platinum = 31·16 per cent.
0·4449 grs. gave 0·6037 grs. chlorid of silver = 33·54 per cent chlorine.

	Eqs.	Calculated.	Found.
Platinum, -	3	30·99	31·16
Chlorine, - -	9	33·42	33·54

Rogojski found in this salt but one and a half equivalents of water, but his analyses are not very satisfactory, giving a large excess of platinum, hydrogen, and cobalt.

CHLORAURATE OF LUTEOCOBALT.

A solution of terchlorid of gold produces immediately in solutions of the chlorid of Luteocobalt a beautiful yellow precipi-

tate of small granular crystals. These crystals are very insoluble in cold water, but more readily soluble in boiling water acidulated with chlorhydric acid. Reducing agents separate gold with full metallic lustre. The formula of this salt is

$$6NH_3.Co_2Cl_3+AuCl_3$$

as the analyses satisfactorily show:

0·7308 grs. gave 0·1025 grs. Co_2O_7 = 10·53 per cent cobalt.
0·7308 grs. gave 0·2530 grs. gold = 34·62 per cent.
0·6457 grs. gave 0·9714 grs. chlorid of silver = 37·36 per cent of chlorine.

	Eqs.	Calculated.	Found.
Cobalt,	2	10·33	10·53
Gold,	1	34·50	34·62
Chlorine,	6	37·30	37·36

IODID OF LUTEOCOBALT.

Iodid of potassium produces immediately in solutions of the chlorid, sulphate, or nitrate of Luteocobalt, a remarkably beautiful bright yellow precipitate of the iodid of Luteocobalt. This precipitate is rather insoluble in cold water, but readily soluble in hot water. The solution yields by spontaneous evaporation brown-yellow crystals, which appear to have the same form as the chlorid.

0·2224 grs. of this salt gave 0·06308 grs. sulphate of cobalt, corresponding to 10·79 per cent cobalt.

The formula $6NH_3.Co_2I_3$ requires 10·88 per cent cobalt.

The color of the precipitated and dried iodid is very fine, and its brilliancy led us to hope that it might be advantageously employed as a pigment. On trial, however, the color was found wanting in body; the yellow, moreover, changes to a brown-yellow when the powder is ground in oil or water.

BROMID OF LUTEOCOBALT.

Bromid of potassium gives a rather dull yellow precipitate in solutions of Luteocobalt. The precipitate, re-dissolved in hot water, gives, on slow evaporation, wine-yellow crystals of the bromid. These crystals have the same form as those of the chlorid, and their formula is therefore

$$6NH_3.Co_2Br_3.$$

COBALTIDCYANID OF LUTEOCOBALT.

Cobaltidcyanid of potassium produces in solutions of Luteocobalt a pale yellowish flesh-colored precipitate of the double cyanid of cobalt and Luteocobalt. The salt is insoluble in cold water, and easily decomposed by boiling water. It cannot, therefore, be re-crystallized for analysis. Under the microscope the crystals are seen to belong to the oblique rhombic system;

they are too small to admit of accurate measurement. The formula of this salt is

$$6NH_3.Co_2Cy_3+Co_2Cy_3+HO.$$

0·4835 grs. gave 0·3923 grs. sulphate of cobalt = 30·88 per cent cobalt.
0·7652 grs. gave 0·3580 grs. water = 5·19 " hydrogen.
2·1645 grs. gave 0·6800 grs. carbonic acid = 13·83 " carbon.

	Eqs.	Calculated.	Found.
Cobalt,	4	30·57	30·88
Carbon,	12	18·70	18·82
Hydrogen,	19	4·93	5·19

A solution of ferridcyanid of potassium produces a most beautiful precipitate of orange-yellow needles in solutions of Luteocobalt. These, under the microscope, have the same form as the corresponding cobalt salt, and their formula is therefore

$$6NH_3.Co_2Cy_3+Fe_2Cy_3+HO.$$

SULPHATE OF LUTEOCOBALT.

The sulphate of Luteocobalt is easily procured mixed with the chlorid, when solutions of both chlorid and sulphate of cobalt are rendered ammoniacal and exposed to the air after the addition of coarsely powdered chlorid of ammonium in large excess. The mass of yellow crystals formed upon the bottom of the vessel, after a few days, is a mixture of the two salts. To obtain the sulphate from this mass, the solution in hot water is to be filtered and digested with sulphate of silver, after addition of a few drops of sulphuric acid. In this manner the whole of the chlorid may be decomposed, and the filtered solution on evaporation will yield fine crystals of the sulphate. We have frequently prepared large quantities of the sulphate by this method. Another mode of preparing the sulphate of Luteocobalt, which is often very convenient, consists in pouring ammonia upon the sulphate of Roseocobalt, thrown down by cautious addition of sulphuric acid to perfectly oxydized solutions of the ammoniacal sulphate of cobalt. When this sulphate is powdered, and strong ammonia poured upon it, its color frequently changes from red to a dull buff, while the supernatant liquid takes a fine red color. The buff powder on solution in hot water and evaporation yields crystals of sulphate of Luteocobalt. The red liquid is merely a solution of sulphate of Roseocobalt in ammonia. The reaction which takes place in this case may be represented by the equation

$$5NH_3.C_2O_3,\ 3SO_3+NH_3=6NH_3.Co_2O_3,\ 3SO_3,$$

the sulphate of Roseocobalt simply absorbing one equivalent of ammonia. The quantity of sulphate of Roseocobalt dissolved in the ammonia is very variable, being sometimes extremely small. In other cases, however, no sulphate of Luteocobalt is

formed, but only a solution of sulphate of Roseocobalt in ammonia, from which, by evaporation, the sulphate crystallizes unchanged in large dark-red crystals, frequently of the form represented in fig. 3. We are unable to assign a satisfactory reason for the capriciousness of the behavior of the red sulphate towards ammonia.

Frémy asserts that sulphuric acid, cautiously added to a completely oxydized ammoniacal solution of sulphate of cobalt, throws down an acid sulphate of Roseocobalt to which he assigns the formula $5NH_3.Co_2O_3, 5SO_3+5HO$. When this acid sulphate is boiled for a few minutes with ammonia, a yellow precipitate of sulphate of Luteocobalt is thrown down. The author does not attempt to explain the reaction which takes place in this case, but states that the red mother liquor from which the sulphate of Luteocobalt has separated, yields on evaporation crystals of the neutral sulphate of Roseocobalt. We have never succeeded in preparing an acid sulphate of Roseocobalt by the process above mentioned, nor by any other. On the contrary, we have uniformly found that sulphuric acid precipitates from the oxydized solution only the neutral sulphate of Roseocobalt in small bright-red crystals, easily recognized by their form. Frémy's salt must have contained free sulphuric acid, in consequence of imperfect washing.

When a pure solution of the sulphate of Roseocobalt is boiled, ammonia is evolved, while sulphate of ammonia and sulphate of Luteocobalt remain in solution, and a dark-colored oxyd of cobalt is precipitated. From the solution the sulphate of Luteocobalt may be obtained by evaporation and crystallization. This method yields but little, and is not to be recommended.

Sulphate of Luteocobalt is also sometimes obtained, with other products, by digesting sulphate of Roseocobalt with sulphuric acid, before the period of complete decomposition sets in.

A very simple and easy method of preparing the sulphate of Luteocobalt consists in decomposing the dry sulphate of Roseocobalt by heat. When the latter salt is gently heated in a porcelain crucible over a spirit lamp, or better still, in a glass flask in a bath of rosin oil to about the temperature of melting lead, ammonia is given off in abundance, and the mass, which should be constantly stirred, assumes a fine purple-lilac hue. The heat, when the lamp alone is used, must never arise to low redness, and no vapors of sulphate of ammonia should be given off. The resulting mass is then to be dissolved in hot water, which gives a fine purple-red solution, and chlorhydric acid added in excess. An orange precipitate of sulphato-chlorid of Luteocobalt is immediately thrown down, which is easily purified, as above, by sulphate of silver and recrystallization. The acid mother liquor sometimes deposits more sulphate on cooling. The supernatant

liquid contains chlorid of Luteocobalt, chlorid of Purpureocobalt, and a leek-green crystalline body, which we have called provisionally Praseocobalt, but which we have not yet carefully studied.

The sulphate of Luteocobalt, like the chlorid, has a fine wine-yellow color, and crystallizes readily. The crystals belong to the right rhombic or trimetric system; they are hemihedral and isomorphous with the chlorid of Luteocobalt. According to Prof. Dana's determinations, the more usual forms are represented in figs. 11, 12, 13, 14. In figs. 13 and 14 the sulphate is mixed with the chlorid.

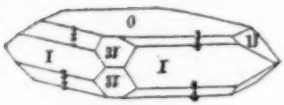
$I : I = 113° 38'$	$O : \frac{1}{2} = 137° 19'$
$O : 1\breve{1} = 146° 4'$	$O : \frac{3}{2} = 118° 28'$
$1\breve{1} : 1\breve{1} = 112° 8'$ (over O)	$O : 3\breve{1} = 107° 57'$
$3\breve{1} : 3\breve{1} = 127° 18'$ (adjacent)	$O : 1\breve{1} = 134° 11'$

$i\frac{\breve{3}}{2} : i\frac{\breve{3}}{2} = 88° 44'$ and $91° 16'$	
$1\breve{1} : 1\breve{1} =$ (over O) $= 88° 22'$	

These forms in other symbols are O, ∞, $3\text{-}\breve{\infty}$, $\frac{3}{2}$, $\frac{1}{2}$, $\frac{3}{2}$, $1\text{-}\breve{\infty}$, (fig. 11). $O, \infty, \frac{3}{2}, \frac{1}{2}, 1\text{-}\breve{\infty}, 3\text{-}\breve{\infty}$ (fig. 12). $1\text{-}\bar{\infty}, \infty\text{-}\frac{\breve{3}}{2}, 3\text{-}\breve{\infty}$ (fig. 13). $1\text{-}\bar{\infty}, \infty\text{-}\frac{\breve{3}}{2}, 3\text{-}\breve{\infty}, 1\text{-}\infty$ (fig. 14).

$$a : b : c = 1{\cdot}039 : 1 : 1{\cdot}539.$$

11.



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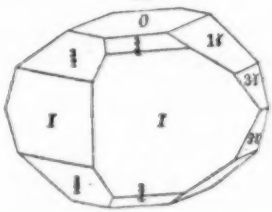

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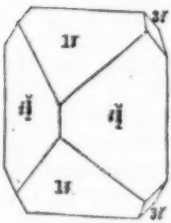
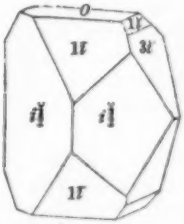


14.



Figs. 15, 16, 17, are different in habit from the preceding, and do not agree precisely in angles. The forms as lettered are referred to a different fundamental form. Adopting the same fundamental form as in the above figures, the lettering would be as follows:

Lettering on figures, O $i\breve{2}$ $1\breve{2}$ $\frac{1}{4}$ $1\breve{1}$ I $i\breve{1}$ $\frac{1}{2}\breve{1}$ $\frac{1}{4}$ $\frac{1}{2}$.
New lettering, O I $\frac{1}{2}$ $\frac{1}{2}\breve{2}$ $3\breve{1}$ $i\breve{2}$ $i\breve{1}$ $\frac{1}{2}\breve{1}$ $\frac{1}{4}\breve{2}$ $\frac{1}{4}\breve{2}$.

Angles obtained and calculated for fig. 13 (putting the lettering on the figure in brackets):

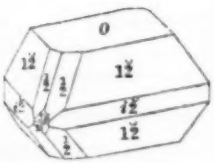
$I:I(i\breve{2}:i\breve{2}) = 64° 28'$ and $115° 32'$ $\quad \frac{1}{2}\breve{2}:\frac{1}{2}\breve{2}, (\frac{1}{4}:\frac{1}{4}) = 124° 3'$ (adjacent).
$O:\frac{1}{2}(O:1\breve{2}) = 120° 36'$ $\quad O:3\breve{1}(O:1\breve{1}) = 119°$.
$O:\frac{1}{2}\breve{2}\ (O\ \frac{1}{4}) = 130° 59'$ $\quad i\breve{2}:i\breve{2} = 103° 10'$ (by calculation).

Angles obtained and calculated for figs. 14, 15:

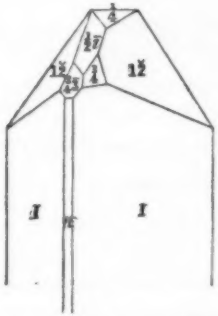
$i\breve{2}:i\breve{2}\ (I:I) = 103° 30'$ $\quad O:\frac{1}{4}\breve{2}\ (O:\frac{1}{4}) = 150° 16'$.
$O:\frac{1}{2}\ (O:1\breve{2}) = 120° 40'$ $\quad O:\frac{1}{4}\breve{2}\ (O:\frac{1}{4}) = 120° 16'$.
$O:\frac{1}{2}1\ (O:\frac{1}{4}1) = 138° 6'$.

Fig. 18 has still a different habit. The occurring vertical prism, lettered I, gave the angle (approximately) 101° 30′, and the dome $1\breve{1}$ has the angle 109° 36′, giving $O:1\breve{1} = 144° 48'$, near the angle in figs. 11, 12.

15.



16.



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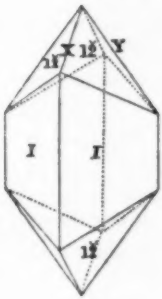
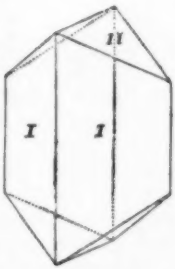


18.



The sulphate is rather insoluble in cold but is freely soluble in hot water; the dilute solution is yellow, the concentrated solution dark sherry wine colored. By double decomposition with salts of barium it yields the other salts of Luteocobalt. The sulphate like the chlorid is dichrous, the ordinary image being pale rose-red while the extraordinary image is bright orange. The color of the salt in coarse powder approaches the orange No. 5 of the first circle.

Sulphuric acid does not precipitate this salt from its solution, but chlorhydric and nitric acids throw down in the cold mixtures of the chlorid with the sulphate and nitrate. The salt is decomposed with very great

difficulty by long boiling, even after the addition of a little ammonia. No new base is formed during the decomposition. When, however, the dry salt is gently heated in a porcelain crucible, ammonia is evolved, and if the heat be regulated so that no sulphate of ammonia is given off, while the mass is constantly stirred, there remains after a few minutes a red mass, which on solution in water gives a fine red liquid containing a sulphate of a red base, which is probably Purpureocobalt. The reaction is, however, a very uncertain one, and has succeeded in our hands but once. We have in most cases obtained by the process described only a mixture of sulphate of Luteocobalt, sulphate of cobalt, and sulphate of ammonia. We shall consider this subject more fully hereafter. Sulphuric acid, if not too dilute, readily decomposes the sulphate of Luteocobalt when the solution is heated. It appears probable that there exists an acid sulphate of this base, as there is an acid carbonate, but we have not been able to obtain it as yet.

Sulphate of Luteocobalt has the formula

$$6NH_3.Co_2O_3, 3SO_3+5HO$$

as the following analyses satisfactorily show. The salt analyzed was dried by pressure between folds of bibulous paper only.

0·3618 grs. gave 0·1600 grs. sulphate of cobalt = 16·83 per cent cobalt.
0·4993 grs. " 0·2205 grs. " " = 16·80 " "
0·4790 grs. " 0·2122 grs. " " = 16·85 " "
1·2023 grs. " 1·2020 grs. sulphate of baryta = 34·32 per cent sulphuric acid.
0·8203 grs. " 0·8250 grs. " " = 34·52 " " "
0·9355 grs. " 0·5650 grs. water = 6·71 per cent hydrogen.
1·1194 grs. " 0·6722 grs. " = 6·67 " "
1·0005 grs. gave 205 c. c. nitrogen at 12°·5 C. and 753^{mm}·61 (at 12°·7) = 191·16 c. c. at 0° and 760^{mm} = 24·00 per cent nitrogen.
0·9018 grs. gave 185·5 c. c. nitrogen at 19° C. and 763^{mm}·36 (at 19°·5) = 171·26 c. c. at 0° and 760^{mm} = 23·85 per cent nitrogen.

Our formula requires

	Eqs.		Calculated.	Mean.	Found.		
Cobalt,	2	59·0	16·85	16·83	16·80	16·85	16·83
Sulph. acid,	3	120·0	34·28	34·42	34·52	34·32	
Hydrogen,	23	23·0	6·57	6·69	6·71	6·67	
Nitrogen,	6	84·0	24·00	23·97	24·00	23·85	
Oxygen,	8	64·0	18·28	18·99	——	——	
		350·0	100·00				

According to Frémy, the sulphate contains but four equivalents of water of crystallization. In vacuo or in dry air the sulphate of Luteocobalt effloresces, becomes opaque and reddish buff colored, and loses 4 eqs. or 10·13 per cent of water.

Rogojski did not succeed in obtaining the sulphate of Luteocobalt by decomposing the chlorid with sulphate of silver. According to this chemist, there is produced under these circumstances a sulphato-chlorid which has the formula

$$6NH_3.Co_2O_3, 3SO_3+6NH_3.Co_2Cl_3.$$

We have already mentioned, however, that the chlorid and sulphate of Luteocobalt are isomorphous, and we have accordingly found, as might be expected, that these two salts are capable of crystallizing together in all proportions, and cannot be separated by crystallization alone. To show the variation in the constitution of the mixed chlorid and sulphate, it will be sufficient to give a few cobalt determinations made with the salt as prepared at different times.

0·1510 grs.	gave	0·0673 grs.	sulphate of	cobalt	= 16·96	per cent cobalt.
0·7075 grs.	"	0·3210 grs.	"	"	= 17·26	" "
0·1205 grs.	"	0·0680 grs.	"	"	= 21·47	" "

The parallel which Rogojski draws between the salt which he analyzed and the sulphate of Gros's base, which Gerhardt considers as a sulphato-chlorid of Diplatinamin, must therefore be considered as illusory.

CHROMATE OF LUTEOCOBALT.

A solution of the neutral chromate of potash gives a fine yellow precipitate in solutions of the chlorid, nitrate, and sulphate of Luteocobalt. The precipitate is soluble in hot water, and crystallizes readily from the solution in brown-yellow crystals, which resemble those of the sulphate. We have not analyzed this salt, but it is almost certain that its true formula is

$$6NH_3.Co_2O_3, 3CrO_3+5HO,$$

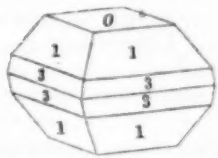
since it forms with chlorid of Luteocobalt crystallizable mixtures in various proportions, which exhibit in the greatest beauty and distinctness the characteristic forms of the crystals of the sulphato-chlorids above alluded to. The pure chromate can only be obtained by precipitating the nitrate of Luteocobalt by chromate of potash, as the precipitate from the chlorid always contains chlorine, and that from the sulphate, sulphuric acid.

NITRATE OF LUTEOCOBALT.

This beautiful salt is almost invariably obtained during the oxydation of an ammoniacal solution of nitrate of cobalt, and is deposited upon the bottom of the vessel in bright orange crystalline scales. The supernatant liquid is usually red, and contains nitrate of Roseocobalt. The orange-yellow salt is easily purified by re-crystallization. The salt may also be easily prepared from the chlorid or sulphate by double decomposition with nitrate of silver or of baryta. The nitrate of Luteocobalt crystallizes readily in forms which belong to the square prismatic or dimetric system. According to Professor Dana, the dimensions and angles of the crystals are as follows:

19.

$1 : 1$ (over the base) $= 110° 20'$
$O : 1 = 124° 50'$
$O : 3 = 103° 4'$
$3 : 3$ (over the base) $= 135° 52'$
$a = 1{\cdot}0161$
$O : i$ (not observed) $= 134° 33'$



The crystals are usually small and often very brilliant. The salt is readily soluble in hot water, and separates in small crystals on cooling. Chlorhydric acid throws it down from its solution as a yellow crystalline powder; nitric acid also precipitates it, but sulphuric acid converts it into sulphate with more or less complete decomposition. The nitrate of Luteocobalt is anhydrous, and has the formula

$$6NH_3 . Co_2O_3, 3NO_5$$

as the following analyses show:

0·1972 grs. gave 0·0880 grs. sulphate of cobalt = 16·98 per cent cobalt.
0·2090 grs. " 0·0928 grs. " " = 16·87 " "
1·0859 grs. " 0·5151 grs. water = 5·27 per cent hydrogen.
0·9126 grs. " 0·4337 grs. " = 5·28 " "
0·6242 grs. gave 188 c. c. at 11°·5 C. and 772^{mm}·40 at 11°·94 = 180·56 c. c. at 0° and 760^{mm} = 36·33 per cent nitrogen.
0·7394 grs. gave 226 c. c. at 13°·5 C. and 766^{mm}·05 at 14° = 213·29 c. c. at 0° and 760^{mm} = 36·23 per cent nitrogen.

The formula requires

	Eqs.	Calculated.	Mean.	Found.	
Cobalt . .	2	17·00	16·93	16·98	16·89
Hydrogen . .	18	5·18	5·27	5·27	5·28
Nitrogen . .	9	36·31	37·28	36·23	36·33

Frémy and Rogojski deduce the same formula from very imperfect analyses. Heat decomposes the dry nitrate of Luteocobalt with a slight explosion, a black powder of an oxyd of cobalt remaining. It may be remarked that the oxygen and hydrogen in this salt are exactly in the ratio to form water.

OXALATE OF LUTEOCOBALT.

When a solution of oxalate of ammonia is added to one of a soluble salt of Luteocobolt, a buff colored precipitate of fine needles is thrown down, which is insoluble both in hot and cold water, but which readily dissolves in a solution of oxalic acid. From this solution the neutral oxalate crystallizes in beautiful prismatic crystals, having the color of the sulphate and chlorid. In dry air the crystals lose water like those of the other hydrated salts of Luteocobalt. The oxalate has the formula

$$6NH_3 . CO_2O_3, 3C_2O_3 + 4HO$$

as the following analyses show:

0·4330 grs. gave 0·2040 grs. sulphate of cobalt = 17·99 per cent cobalt.
0·4228 grs. gave 0·2000 grs. " " = 18·00 " "
0·5345 grs. gave 0·2529 grs. " " = 18·01 " "
2·0805 grs. gave 0·8380 grs. carbonic acid = 32·95 per cent oxalic acid.

The formula requires

	Eqs.	Calculated.	Found.		
Cobalt . . .	2	17·93	17·99	18·00	18·01
Oxalic acid . .	3	32·82	32·95	——	——

It would *à priori* appear probable that there exists an acid oxalate of Luteocobalt corresponding to the acid carbonate, but we have not yet been able to obtain such a salt. The oxalic acid in this compound cannot be easily reduced by a solution of terchlorid of gold, nor can it be completely separated from the base by means of a solution of chlorid of calcium.

CARBONATES OF LUTEOCOBALT.

The neutral carbonate of Luteocobalt is readily formed by decomposing a solution of chlorid of Luteocobalt by carbonate of silver. The yellow solution, by evaporation, yields sherry-wine colored crystals of the carbonate. The salt closely resembles the other soluble salts of Luteocobalt; is easily soluble in hot water, and crystallizes well by slow evaporation. During evaporation, however, the solution absorbs carbonic acid from the air, and crystals of the acid carbonate are found mixed with those of the neutral salt. According to Prof. Dana's measurement, the crystals of the neutral carbonate belong to the trimetric system, and approach aragonite in form. Fig. 20 represents a crystal of this salt:

20.

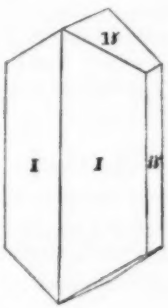
$I : I = 116° 50'$

$I : i\bar{1} = 121° 35'$

$1\!\!1 : 1\!\!1$ (top) $= 114° 16'$

$1\!\!1 : 1\!\!1$ (over) $i\bar{1} = 65° 44'$

$a : b : c = 1{\cdot}0509 : 1 : 1{\cdot}6265$



The constitution of the neutral carbonate appears to be represented by the formula

$$6NH_3.Co_2O_3, 3CO_2 + 7HO.$$

0·2495 grs. gave 0·1220 grs. sulphate of cobalt = 18·61 per cent cobalt.
0·3518 grs. gave 0·0786 grs. carbonic acid = 22·34 per cent.

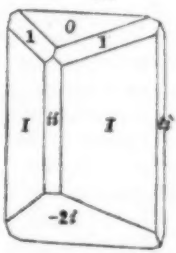
The formula requires

	Eqs.		Found.
Cobalt, - -	2	18·79	18·61
Carbonic acid - -	3	21·01	22·34

The excess of carbonic acid and the deficiency in cobalt, are doubtless due to the presence of a portion of the acid carbonate. The neutral carbonate loses its water of crystallization in dry air, and becomes opaque, with the lustre of porcelain, like many other hydrated salts of this base.

The acid carbonate of Luteocobalt is most readily prepared by passing a current of carbonic acid gas into a solution of the neutral salt. The acid carbonate usually separates, after a very short time, in the form of large brown-red or sherry-wine colored crystals, which are less soluble than those of the neutral carbonate. According to Prof. Dana, the crystals of this salt belong to the monoclinic system, and closely approach Barytocalcite in form. Fig. 21 represents a crystal of this salt.

21.



$O : i̇i̇ = 108° 16'$
$O : I = 77° 40'$ and $102° 20'$
$I : I = 85° 54'$
$O : 1 = 139° 50'$
$I : 1 = 142° 30'$
$O : -2i = 111° 46'$
$a : b : c = 0·7219 : 1 : 0·8398.$
$C = 71° 44'.$

In Barytocalcite the angle corresponding to $O : i̇i̇ = 106° 54'$ and that corresponding to $I : I = 84° 52'$.

The acid carbonate of Luteocobalt retains its water of crystallization in the air, but loses it under the air-pump. The salt is particularly interesting as being the only acid salt of Luteocobalt which we have as yet been able to obtain. The formula of this salt is

$$6NH_3.Co_2O_3, 3CO_2+HO, CO_2+5HO$$

as the following analyses show:

0·4715 grs. gave 0·2246 grs. sulphate of cobalt = 18·12 per cent cobalt.
1·0506 grs. gave 0·2830 grs. carbonic acid = 26·93 per cent.

The formula requires

	Eqs.		Found.
Cobalt, - - -	2	18·04	18·12
Carbonic acid, - -	4	26·91	26·93

The very distinctly marked triacid character of Luteocobalt, considered as a base, renders it, to say the least, improbable that the formula of this salt should be written

$$6NH_3.Co_2O_3.4CO_2+6HO.$$

OXYD OF LUTEOCOBALT.

The oxyd of Luteocobalt may be obtained by decomposing a solution of the sulphate with baryta water. The solution is brown-yellow, and has an alkaline taste and reaction. It cannot be evaporated without decomposition, ammonia being evolved and a black powder separated. The solution absorbs carbonic acid from the air, and on evaporation, yields crystals of the carbonates; with acids it yields the salts of the base. The oxyd of Luteocobalt appears to form compounds with salts of copper, which may be analogous to the ammonia-salts of that metal, or which again may be only double salts of copper and Luteocobalt. A solution of the oxyd added to one of sulphate of copper gives, after standing, beautiful chrome-green crystals of a new salt, which we have not yet had an opportunity of examining.

(To be concluded.)

ART. XXXIV.—*Earthquakes in California during the year* 1856; by Dr. J. B. TRASK.*

AT the close of 1855, I presented to the Association a statement of the occurrence of earthquakes in this state for that year and a term of years preceding.

During the year just passed, I have kept a careful record of these phenomena, that have been noticed in this city, and other parts of the State, which will be found below, with their dates, and the hour of the day on which they took place. They comprise all that have occurred, with perhaps two exceptions, the dates for which were so obscure as to render it impossible to determine with accuracy the precise period of their occurence. So far as I am informed, those shocks which have taken place in this State during the past year have not been marked with more severity than has been usual in years preceding. They frequently amounted to a slight tremor, and at other times to more distinct movements; three only possessed sufficient intensity to command general attention during the busy hours of day.

Very few have been noticed by persons who were standing upon the earth at the period of their occurrence. By far the greater proportion were observed in high situations from the ground, and in the more retired parts of the city, or on the alluvial covering of the country to the west and south.

The total number for the past year is sixteen, and of this number thirteen were observed between sunset and sunrise, a fact

* Read before the California Academy of Natural Sciences, at San Francisco, January 12, 1857.

sufficient in itself to show the lightness of their character; for, did they possess that severity so often attributed to them, the attention of the people would much more often be directed to them. Yet we find that their first knowledge of such an occurrence is usually its announcement by the daily press.

By reference to the statistics below, it will be seen that even in the mountain districts, where during the day there is much less of turmoil and noise arising from business than in the populous city, of all these noticed, none have been of sufficient intensity to attract the attention of the inhabitants during the hours of daylight. These facts, though few in themselves, are of importance, to disabuse the public mind in relation to the danger to be apprehended from the occurrence of these phenomena. The reputation which we sustain both at home and abroad, of being in constant danger of being swallowed up by these occurences, and the idea that our country is but a bed of latent volcanoes, ready to burst forth at any moment, spreading devastation over the land, is a very needless source of alarm.

We should remember that when speaking of California as a state, that we include a line of territory equalling that of the seaboard lying between Cape Hatteras on the south and the British Possessions on the north, and including eleven of the seaboard States of the Union; and when we place our comparative estimates on this basis, in matters of this character, it will become at once evident that the danger of annihilation from the causes under consideration, are not of that magnitude that at first sight would appear.

Along the coast of Mexico and Central America, to the south of California, from all the records that are obtainable here, there appears to have been a much greater exemption from those phenomena than has been usual in former years; this seems to have been the fact, also, throughout the Pacific, Oceanic and most of the continental islands along the coast of China, while to the north and northwest, beyond the fifty-fifth parallel, both volcanic and earthquake phenomena appear to have been more violent than usual. This has been observable, for the most part, in the neighborhood of the Aleutian Archipelago, along the northeast coast of Japan, and in the British and Russian Possessions of North America on the Pacific, and islands of the Ochotsk Sea.

It would be interesting to know more about these phenomena in those regions, and such information could be easily obtained from the commanders of the whaling fleet, if the proper measures were adopted to secure it.

Below will be found some interesting facts upon this subject, observed during the past year near the Straits of Ourinach.

The earthquakes which have occurred in this State during 1856, and the period of their occurrence, are as follows:

Jan. 2.—At a quarter before ten this morning, a smart shock of an earthquake was felt in San Francisco. The motion of the earth was undulatory, and came apparently from the northward. A pendulum indicated a motion of about five and a half inches.

Jan. 28.—At the town of Petaluma, Sonoma County, a shock of an earthquake occurred at a few minutes past three o'clock in the morning. It was sufficiently heavy to awake persons from their sleep.

Jan. 29.—At a quarter before one o'clock this morning, a slight shock was felt in San Francisco.—It was observed also at the Mission Dolores. There were three distinct tremors, with short intervals elapsing between. The motion was apparently from the westward.

Jan. 31.—Quite a smart shock occurred at four o'clock this evening; it was quite sharp in the southwest part of the city.

Feb. 15.—At five o'clock twenty-five minutes a severe shock of an earthquake was felt in San Francisco, the duration of which was about eight seconds. Persons sleeping were aroused, and many persons left their beds and sought the street. There were two distinct shocks, the second very light and scarcely perceptible. The motion was *undulatory* and *vortical*, and at the end of the first shock a very strong, profound jar, with which it ceased.

The upper part of a building on Battery street, for seventy feet in length, was thrown down, the whole that was above the cornice; but the mortar with which it was constructed had not become hardened, being easily removed by the fingers; it more resembled wet sand than a firm mortar.

There appears to have been but little difference in the sensations of persons situated either in upper or basement stories. It was preceded by a deep, heavy rumbling, and the motion apparently came from the northwest. A distinct shock was felt at eight minutes past two o'clock the same morning, by persons who were awake and up at the time.

The vortical movement was shown in the fact that small square bottles and boxes that stood upon a line, were moved from their position horizontally, describing an arc of thirty degrees and upwards, as shown by the dust upon the shelves on which they stood.

The first wave came with a force sufficient to project small articles three or four feet on the floor, from shelves on which they were placed; they were apparently all thrown in the same direction. Several clocks were stopped at precisely five hours twenty-five minutes.

All the cracks in walls and ceilings had a direction nearly northwest and southeast, and most of them had the appearance of having been produced at the moment of elevation.

The earthquake was felt heavily at Monterey, at 5 hours 20 minutes; it was also felt at Bodega, but no time is given.

The vessels on the coast, and ranging from San Pedro on the south to Southern Oregon, and at distances varying from eight to one hundred miles from land, did not experience any shock. They were twenty-two in number.

Up to the present date the most northern point of which we have any record of its having been felt, is at Santa Rosa, which is fifty-three miles north of San Francisco, and at Monterey, ninety miles south of the latter place; to the east of this city we have no record beyond Stockton. This would give for its length one hundred and forty-three miles, and its breadth sixty-six miles.

Inquiry was made through the State line Telegraph at El Dorado, Nevada, Downieville, Placerville, Marysville, Sacramento, Stockton, and San José; it was not felt in any of the localities named, excepting the two last, and at Stockton it was quite light.

If the time as given at Monterey was the same as at this city, (San Francisco) the velocity of the earth-wave must have been much slower than that of the great earthquake at Simoda.

March 24.—A slight shock was felt at Canal Gulch, Siskiyou county, also at Yreka, at 20 minutes before 10 o'clock, P. M. The motion is described as being horizontal.

March 31.—A light shock was felt in San Francisco at 25 minutes past 1 o'clock, A. M. It consisted of three light but distinct tremors.

April 6.—11½ P. M, A smart shock was felt at Los Angeles and the Monte. People were aroused from their beds.

May 10.—A light shock was felt in San Francisco at 10 minutes after 9 o'clock, P. M. The shock was accompanied by a loud report, like the discharge of a cannon; people mistook it for the signal gun of the mail steamer. This was felt at Monterey, Contra Costa county.

May 2.—A severe shock was felt at Los Angeles a few minutes past 12 o'clock P. M. It caused much trembling among the buildings, and considerable alarm among the people, many leaving their beds. The shock was preceded by two loud reports like the blasting of rock; it apparently came from the northwest; no damage was done.

August 2.—A light shock was felt in San Francisco at 20 minutes after 5 o'clock A. M. It was sufficiently strong to awaken persons in bed; it was evidently more severe in Stockton.

August 27.—An earthquake was felt at Mission San Juan, Monterey County, at 15 minutes before 9 o'clock P. M. There were two distinct shocks with short intervals elapsing, the second

being the heaviest. The motion is described as undulatory and coming from the west. It was felt at Monterey and at Santa Cruz.

Sept. 6.—A smart shock felt at Santa Cruz, at 3 o'clock A. M. It created considerable consternation and many persons left their beds.

Sept. 20.—A very severe shock was felt in different parts of San Diego county, and at that town at 11½ o'clock, P. M. At Santa Isabel the ceilings of the dwellings was shaken down; the cattle stamped and ran bellowing in all directions, and the Indians seemed equally terrified. The walls of the adobe buildings were many of them cracked. The motion is described as oscillatory. A light shock occurred on the following Monday evening.

Nov. 12.—A smart shock occurred at Humboldt Bay at 4 o'clock, A. M. Another shock was reported, but no date given.

From the records before us it will be seen that fourteen being the total number of earthquakes recorded during 1856, seven have been felt in San Francisco in common with other parts of the state; seven have occurred south of this locality that were not observed here, and four north of it. Of the seven shocks noticed here, five only were not observed in any adjacent district, and may be considered as strictly local. The periods of the year at which the shocks have occurred, is as follows: During the winter months, five; during the autumn, three; during the spring and summer, six. Nine have taken place during the vernal and autumnal equinoxes.

We have records of considerable and violent volcanic phenomena throughout the northern seas, and islands both to the east and west of Alaska. The Russian frigate *Dwina*, while lying at Shuam Sbu, brings intelligence of the outburst of a volcano in that city about the 22nd of June, and on the 25th of the same month passed through fields of floating pumice; the latitude by observation being 50° 53′ and longitude 158° 32′ east per chronometer.

An interesting account of a submarine volcano was reported by the Captain of the bark *Alice Frazer*, in latitude 54° 36′; longitude 135° west, which is as follows: A portion of the whaling fleet, four in number, were running through the Straits of Ourinack, on the 26th of July last; while passing the straits a submarine volcano burst out, sending a column of water several hundred feet upward; immediately following this, immense masses of lava were projected into the air, and the sea for miles and for days afterward, was covered with floating fragments of pumice. The ships *Scotland* and *Enterprise* were nearer the volcano than the ships *Frazer* and *Wm. Thomson;* on the decks of

the two former considerable pumice, lava, and ashes fell. There were seven vessels in the straits at the time of the occurrence, the names of three of which I could not learn.

The outburst was accompanied with violent shocks of earthquake. It is the opinion of Captain Newell, of the *Alice Frazer*, that considerable shoaling has been the result of this submarine action.

ART. XXXV.—*On the Formation of Craters, and the Nature of the Liquidity of Lavas*;* by G. POULETT SCROPE, Esq., M.P., F.R.S., F.G.S.

CONTENTS.

Introduction.
I. Formation of Cones and Craters.
Hypotheses of crater-formation by "Elevation," "Denudation," and "Engulfment."
Circular form of Craters.
History of Vesuvius.
II. Nature of the Liquidity of Lavas.
Plutonic rocks.
Lamination, cleavage, and foldings of rocks.

Introduction.—It is now some thirty years since I published two works† upon the phenomena of Volcanos, Active and Extinct. I described in them as accurately as I could, by pen and pencil, what I had observed during a residence of some duration among the volcanic districts of France and Italy; and explained, in considerable detail, the laws which, from those observations, I believed to regulate the remarkable developments of subterranean energies usually called volcanic, which have played so important a part in the construction of the superficial crust of our planet.

The general principle on which I proceeded in the theoretical portion of these works was the same which had been previously employed by Hutton and Playfair, and was subsequently adopted, with signal success, by Sir Charles Lyell,—namely, to refer, so far as is possible, appearances, the origin of which has not been witnessed, to such causes as are seen or known to produce analogous appearances in the present day,—instead of resorting for the purpose to imaginary hypotheses.

In the earlier volume of the two (the Considerations on Volcanos), however, I certainly overstepped this wholesome rule, by entering towards the conclusion of the work upon some rather crude speculations on a general theory of the globe; and this, together with defects of style and arrangement, and likewise of illustration, of which I became sensible only when it was too

* Cited from Journ. Geol. Soc., xii, 326.

† "Considerations on Volcanos," &c., 1825–6. "On the Geology of Central France," &c., 1826–7.

late to amend them, sufficiently accounts for the different reception these two works met with from geologists at the time. Neither, however, I presume to hope, were wholly without some beneficial result. At the period of their publication, the Wernerian theory of the precipitation from some aqueous menstruum, not merely of granite, and what were then called the primitive formations, but even of all the trap-rocks, still prevailed, and had the support of a large school of geologists in this country. I venture to think that the facts reported in my two volumes (especially those represented to the eye in the atlas illustrative of the volcanic remains of Central France) had some share in the final extinction of that German romance,—which some geologists as old as myself may remember to have been regarded almost in the light of a gospel-truth, and defended with great acrimony.

Some of the opinions, however, expressed in these works with respect to the laws that govern volcanic action, were severely criticised at the time. Others have been since opposed by rival theories. And, as these disputed questions have an important bearing on some of the most interesting problems of geology, I trust it may not be unprofitable to call the attention of our Society to the more prominent among them.

I will advert on this occasion to two subjects especially, viz:

I. The origin, or mode of formation, of volcanic cones and craters.

II. The nature of the liquidity of lava at the time of its protrusion from a volcanic aperture.

I. *Formation of Cones and Craters.*—In both of the works to which I have alluded, I referred the formation of those remarkable circular hollows, usually called craters, which are of so frequent occurrence in volcanic districts, to explosive aëriform eruptions, breaking their way through the superficial rocks; and that of the external more or less conical hill or mountain which generally, but not always, environs a crater, and which, indeed, often occurs without a crater, but always characterized by the qua-qua-versal dip of its constituent beds of lava and conglomerates,—to the accumulation round and above an eruptive vent, of its fragmentary ejections and the lava streams poured out from it.

I considered this law to be without exception; attributing the differences in figure and structure apparent among volcanic cones to the greater or less number and violence of the eruptions to which they were owing,—some being the product of a single eruption, others of a vast number, often repeated through a series of ages,—to differences in the position of the orifices of discharge, whether from the summit of the cone, or its base, or any

intermediate points,—and whether from under water, or in the air,—to the varying mineral character of the products,—and to the influences of subsequent degradation.

At the same time I remarked that the earthquakes which always more or less accompany volcanic eruptions render probable a certain amount of elevation in mass of the pre-existing superficial rocks; and moreover that the rents they cause in the solid substance of the cone of a volcano in repeated eruption, into many of which rents liquid lava will be injected from the column rising in the central chimney, and cool down afterwards into more or less vertical dykes of solid rock, must have added considerably to the bulk and elevation of such a mountain, by a sort of inward distension.

This was no closet-theory,—because as respects the cone and crater of Vesuvius at least, I had the advantage, in the years 1818, 1819, and 1820, of watching with my own eyes the outward growth of that cone, through a series of almost continual eruptions of a comparatively tranquil character, which during those years added considerably to its height and bulk by external accretions of ejected scoria and lava-currents. These last, the lava-streams, issued from small cones and craters formed upon the solid platform which then composed the summit of the great cone, and dribbled slowly down its slopes, consolidating so rapidly there as in few instances to reach the base of the cone at all; although night after night they were to be seen flowing from the summit in streams of considerable breadth and bulk, and glowing with a bright light on its steep sides.

Afterwards, in the latter part of the year 1822, I had seen the upper portion of this solid cone blown into the air (by which it lost a full third of its height), and a crater of vast dimensions drilled through its axis by continuous eruptive explosions of twenty days' duration.

I had previously made a close examination of the cones and craters of Etna, the Phlegræan Fields, the Lipari Isles, Central France, and the Rhine district; and their appearances accorded so completely with the supposition of an analogous mode of formation in these instances, that, upon the principle of explaining the unknown by the known, it seemed impossible, or at least unnecessary, to imagine any other origin for them.

"*Elevation*," "*Denudation*," *and* "*Engulfment*" *Theories of Crater-formation.*—It was, therefore, with no small surprise that I have since found this simple and natural mode of production denied to all cones and craters—including those of Vesuvius itself; and an hypothesis substituted of their originating in some sudden elevation of previously horizontal beds around a centre,—not (it would seem) of eruption, but of maximum elevation. I allude, of course, to the "Elevation-crater theory" of MM. Von Buch and Elie De Beaumont.

Sir Charles Lyell, M. Constant Prevost, and others have amply refuted this unphilosophical theory; which, however, still appears to hold its ground to some extent on the Continent, through the prestige of the great names attached to it. It may, therefore, not be wholly useless to adduce some additional proofs of its unwarrantable character. But I must first be permitted to remark, that even Sir Charles Lyell while supporting the view indicated above, of the generally eruptive origin of volcanic cones, has had recourse, in the case of some craters, to another agency, the influence of which I am induced to think he overrates;—I mean the excavating power of the sea in forming what he calls "craters of denudation." This phrase, I think, he first employed in a paper on the subject read before this Society in December, 1849. It is not repeated in the latest edition of his "Principles," and I imagine, therefore, that he is no longer desirous of maintaining its propriety.

I by no means doubt, that in the case of craters formed beneath the sea, or in such close vicinity to it as to allow its waves and currents to enter and sweep round their interiors, these circumstances must have considerably modified the result. In the former case, that of subaqueous eruption, the resistance of the water above the vent would probably tend to throw off the ejected materials over a wider area. And thus, perhaps, we may account for the vast horizontal dimensions of the great crateriform basins of Italy,—Bolsena, Bracciano, Albano, and others, evidently of submarine origin. In the latter case, that of subaërial craters to which the sea has had access through some lateral opening, no doubt great degradation of their internal slopes and cliffs, as well as of the outside, will have often taken place. Many, indeed, will have had their enclosures reduced to a mere skeleton, like Santorin. Some, like Graham's Isle, have been entirely swept away. But the question being as to the *origin* of these crateriform hollows, not as to the cause of any subsequent alteration of figure, this, I believe, may in every instance, without exception, be most reasonably referred to volcanic explosive eruptions. And, therefore, the employment of such a phrase as "craters of denudation," in contradistinction to "craters of eruption," can only lead to a wrong conception of the originating forces.

Where, indeed, is to be found a crater, the formation of which cannot be accounted for (making allowance for the subsequent modifications already referred to) by eruptive phenomena of the same character as those which have, before the eyes of trustworthy observers, repeatedly drilled enormous craters through the axis of the cone of Vesuvius?

Is it the vast size of some craters which should render such an origin incredible in their instances? For example,—of the

Val di Bué on the flank of Etna, the Caldera of Teneriffe, that of Palma, Santorini, or the external crater of Barren Island; which measure some three, five, or even six miles in diameter? But the crater of Vesuvius, formed in 1822, before my eyes, by explosions lasting twenty days, measured a mile in diameter, and was more than a thousand feet deep. The old crater of Somma, which half encircles the cone of Vesuvius, is about three times as wide as the crater of 1822. Are we, then, on that account alone, to believe that it could not have been produced by an eruption of proportionately greater violence,—when, too, such an eruption is known to have occurred about the time this crater must have been formed, namely in the year 79, and to have overwhelmed three cities at the base of the mountain beneath its enormous fragmentary ejections? Is it not, on the contrary, much more in accordance with sound philosophy to ascribe the excavation of the old concentric crater of Somma to the same cause which but the other day was seen to excavate the new crater of Vesuvius, through the heart of the same mountain, than to invent for the former a different and fanciful process? But if Somma be admitted, notwithstanding its extent, to be a true crater of eruption, the same origin cannot be denied to that of Palma, Santorini, or others, on the ground of their size, which scarcely, if at all, exceeds that of Somma.

Sir Charles Lyell seems to doubt the Val di Bué being a true crater of eruption upon two grounds. First, because the beds composing the surrounding cliffs do not show the usual qua-qua-versal dip, but generally slope towards the sea. This, however, is merely the result of the eruption, having broken out on one side of the central axis of the mountain,—a circumstance of frequent occurrence; and naturally so, because the old central vent is apt to be sealed up by the consolidated products of former eruptions, and the point of least resistance to the subterranean eruptive force will often, therefore, be a little on one side,—probably on a fresh point of a fissure broken through the flank of the mountain.

In fact, there must be a contest between the resisting powers of the sides of the mountain and of its upper part; and the weakest part, whichever it is, will give way, and be blown up.

Sir Charles's second reason is, that a sufficient amount of conglomerates is not to be seen on the mountain-slopes around the Val di Bué, to account for the vacuity. But, besides that he himself speaks of "enormous masses of scoria on the flanks of Etna," it should be remembered that the aëriform explosions, when long continued, triturate the ejected matters, owing to their repeated fall into and rejection from the crater, to such a degree as to reduce the greater part at length to an impalpable powder, which is carried by the winds to a distance, sometimes

of hundreds of miles, and spread in a thin layer over an enormous area of sea or land. And, moreover, the larger the dimensions of any crater, the more powerful and enduring will have been, in all probability, the explosions, and the more thoroughly triturated, during the process of its gradual enlargement, would be the fragments thrown up by them.

I remember being exceedingly surprised, after the termination of the Vesuvian eruption of 1822, forming a continual fountain of stones and ashes some miles in height, lasting through twenty days, and in the end completely gutting the mountain, to find that the prodigious amount of fragmentary matter thrown out from the crater had coated the outer slopes of the mountain only to an average thickness of a foot or two at most. But then the ashes which day by day were reduced to a finer and at length to an impalpable powder, so fine as to penetrate the closest rooms in the houses of Naples, were borne to vast distances by the winds. Much, too, was carried down into the plain, or the sea below the mountain, by the torrents of rain (producing *lave di fango*, or mud-lavas), such as overwhelmed Herculaneum, and which accompanied, as usual, the paroxysmal eruption of 1822.

Indeed, if we consider the statements adduced on good authority, of the prodigious distances to which ashes, and even large fragments of lapillo and of pumice, have been occasionally borne away from some of the volcanoes of South America and the Pacific (as, for example, in the eruption of Coseguina in 1835, and of Galongoon in 1822),—distances of more than a thousand miles (a large segment of the circumference of the globe), the whole of which intermediate space must have been strewn with them (and, in the first of these instances, it is said, to the depth of ten feet, at the distance of twenty-four miles from the volcano), we may well conceive that eruptions productive of such an enormous amount of ejected matters may (nay, must) have blown into the air entire mountains of a magnitude far exceeding that of Vesuvius and Somma itself, or the bulk of matter wanting in the Val di Bué, and left in their place craters of corresponding dimensions.

Sir Charles Lyell suggests (as others have done before him), in regard to some of the largest known craters, another possible origin, which he calls *Engulfment*—that is, the subsidence of the upper part, or a large area, of a volcanic mountain into some abyss suddenly opened beneath. With respect to this supposition, without attempting to dispute its possibility, I must say that I am not aware of any such process having been ever witnessed by any credible observer so placed as to be able to distinguish between engulfment and ejection; and consequently that it were well to be cautious in admitting the occurrence of such a phenomenon, if the ordinary mode of action be sufficient to explain the facts really observed. We possess reports, it is true, of

eruptions and earthquakes in Java, Sumatra, the Andes, and elsewhere, having caused the disappearance of the entire summit of a mountain, leaving a vast cavity in its place. But this is precisely the result that was observable after the eruption of Vesuvius in 1822. And in that instance we know there was no subsidence. The leading example usually adduced of such immense (supposed) engulfments is the truncation of the lofty cone of Papandayang, in Java, by an eruption in the year 1772. There, it is always said, a great area of the volcano "fell in and disappeared," swallowed up in the bowels of the earth, together with forty villages and their inhabitants. Such are the phrases usually made use of on these occasions, and very naturally so, by alarmed and unscientific observers. But recent explorers, especially Professor Junghuhn, have stated that these towns and villages of Papandayang were not swallowed up at all, but buried, like Pompeii, under the ejectamenta of the volcano; and Dr. Junghuhn, therefore, very properly refers the truncation of the mountain to eruptive explosions, rather than to subsidence.

It is, no doubt, quite conceivable, that within a volcanic mountain some internal reservoir, or subterranean lake of liquified lava, coated over by a crust of hardened rock or the accumulation of fragmentary matter, may be *tapped*, as it were, by an earthquake, and empty itself out of an aperture in the side of the mountain at a low level, leaving a cavity, which another earthquake, or the explosion of vapor and gases accumulated within it and increasing in temperature, may cause to burst like a vast bubble,—the overlying crust of rocks falling inwards. But such a supposition is in the present state of our knowledge, purely conjectural, and unwarranted, if, as I have endeavored to show, the ordinary phenomena of eruption suffice to account for the formation of the largest known craters. If it is to be resorted to, in any case, it would be, perhaps, in that of the very small pit-craters, occasionally met with in volcanic districts, such as the Gour de Tazana, and the lakes Pavin du Bouchet, and Servières in Central France. But even these show marks of explosive eruption in the scoria sprinkled around their banks. And the occurrence of even a single bed of scoria is certain proof of some explosions having taken place from a body of liquid lava beneath; though, as I have said, this *may* have been accompanied or followed by engulfment. Perhaps the singular character of the crater of Kilauea, in Owyhee, may be thought to claim for it an origin in subsidence rather than eruption. It is described as a vast sudden depression in what would otherwise be almost a level plain, on the side of the gently sloping volcanic mountain of Mauna Loa. It has an irregularly oval form, from three to five miles in diameter, and is usually encircled by vertical cliffs some hundred feet high. Its bottom consists of a lake of lava, on some points (which occasionally change their situa-

tion) in continual ebullition, and at a white heat; but coated over for the most part by an indurated crust upon which it is often possible to walk. Sometimes, however, the incrusted portion is in the centre of the lake, forming a rough platform, surrounded by a circle of incandescent and seemingly fused lava,—sometimes the outer circle forms a solid shelf, within which an inner basin of lava boils at a greater or less depth below its edge. It is evident, from the account of this crater given by Professor Dana, in the "American Journal of Science," as gathered from the relations of various observers during nearly a century past, that the surface of a vast boiling lake of subterranean lava existing here, rises and sinks at irregular intervals of several years in duration; sometimes filling the entire cavity, and even pouring over its outer margin sheets of a very liquid lava,—sometimes sinking to a depth of a thousand feet or more,—especially when some outburst from a lower vent, or chain of vents, has *tapped* the internal reservoir. But, however, interesting the characteristic features of this crater, both from the facilities it affords for observation, and the great scale on which they are developed, they do not seem to me to prove the origin of the cavity other than that of ordinary craters. The phenomena of Kilauea are not so exceptional as, at first view, might be supposed. Visitors who looked down into the great Vesuvian crater for a few years after its formation in 1822, saw pools of liquid and incandescent lava at its bottom, and small cones of scoria thrown up by an almost constant ebullition. The difference in the violence of the explosions, and in the amount of ejected scoria, arises, no doubt, as Professor Dana very justly observes, from the difference in the relative liquidity of the lavas,—those of Kilauea being very liquid, those of Vesuvius much more viscid and unyielding.* So also during the Vesuvian eruption

* Dana, "American Journal," 1850, vol. ix, p. 383.

Note by J. D. Dana.—I do not regard the origin of the crater of Kilauea essentially different from that of other craters. But there is this peculiarity, that the lavas have not in modern times, at least, overflowed the pit; and moreover the country around, neither in its height or slopes or scoria bears evidence of long continued overflows. There is no cone about the crater. It is a pit, which certainly overflowed at first, but for a long period has discharged itself by lateral fissures. There are several other large pit craters in the vicinity of Kilauea which are without any cones or slopes around them, being literally pits; they once contained boiling lavas to their top like the small active pools in the bottom of Kilauea, but a subterranean opening discharged them and left a deep pit with vertical walls like Kilauea. The sides of the walls in such a case are as clear from scoria as a cliff of stratified limestone, because the undermining, owing to the drawing off of the lavas, caused the sides to a certain distance around to fall from want of support, and so leave fresh fractures. I have attributed the origin of the Val di Bué (Bové) of Etna to the same cause that has produced Kilauea, and I still believe the view right. There is in a certain sense an "engulfment;" and so there is in the eruptions of Vesuvius. Mr. Scrope writes as if I had described from the observations of others alone, and does not appear to have seen my Report on the Volcanoes of the Pacific in my Geological volume connected with the Exploring Expedition.

of 1753, persons who ventured to the summit of the cone observed jets of liquid lava thrown up from the surface of a mass which occupied the bottom of the crater, and conducted itself exactly in the manner of a liquid in ebullition. Spallanzani remarked a similar appearance within the great crater of Etna in 1788. In the volcano of the Isle of Bourbon, Bory de St. Vincent describes a source of very liquid and glassy lava ceaselessly and somewhat tranquilly boiling over in concentric waves from the summit of a dome-shaped hillock composed of its overflowings.

Circular form of Craters.—A consideration which has not, perhaps, been sufficiently adverted to by geologists speculating on the origin of volcanic craters, is the cause of their invariably circular or nearly circular figure. If I am right in attributing their formation exclusively to aëriform explosions, it follows that each is in fact simply the external orifice of a more or less cylindrical bore drilled through the preëxistent rocks by repeated discharges of highly expansive aëriform fluids (probably for the most part steam) forcing their way upwards at some weak point; and that it is to the equal pressure in all directions of the expanding fluid that the circular form of the section of this orifice is due,—the same cause, in fact, which gives a spherical form to a bubble of air or gas rising through water. Indeed the eruptive explosions must be considered as occasioned by the rise of a succession of enormous bubbles from a great depth in the fluid lava below. Each single explosion attests the bursting of such a bubble from the surface of the liquid mass of lava in the vent. In moderately tranquil eruptions these succeed each other at considerable intervals. In the case of Stromboli, I noted that about five minutes usually occurred between every two explosions. When the eruption assumes a violent character, as in the Vesuvian one of 1822, the eructations, for such they are, succeed each other so rapidly as to produce an almost continuous roar, like the blowing off of a thousand steam-boilers. And each explosion gives birth to one of those great globular volumes of white vapor, which, rolling over and over each other as they rise in the air in a vast column, occasion one of the most remarkable and magnificent appearances of a paroxysmal volcanic eruption. In the midst of these clouds of snowy vapor, a black column of stones, scoria, and ashes may be seen to shoot up to a vast height, generally attended with copious discharges of electricity generated by the friction of the ejected fragments, and forming a singular contrast to the jet of aëriform matters.

In some rare cases it is possible to witness the actual rise and bursting of these great bubbles of vapor. Spallanzani on his visit to Stromboli in 1780 saw the liquid surface of lava at a white heat within the orifice of the volcano surge alternately

upwards, and after bursting like a great bubble, fall back again out of sight. In 1819 I was myself able to witness the same interesting phenomenon probably from the same position, a high point of the external crater-rim which overlooks the vent. At each belch, a shower of tattered fragments of lava, torn from the surface of the bubble as it broke, rose into the air with a cloud of vapor and a fierce roar; while steam seemed to be at intervals blowing off from another neighboring vent. Hoffman, who visited the same volcano a few years later, describes in minute detail precisely the same phenomena.

The vast size of some craters, already noticed, may afford a notion of the enormous volumes of gaseiform matter that must have been discharged through them at the time of their formation by continuous explosions lasting for weeks and even months; since each individual bubble of vapor must have been of a magnitude to fill the entire horizontal section of the crater; and even for some time to aid in enlarging the area of this aperture by violent pressure against its rocky sides. The prodigious force with which they ascend, and therefore the great depth at which they are generated, may be judged from the vast vertical height, measured in miles, to which they have been seen to shoot up a continuous columnar fountain of ejections, consisting not merely of scoria and ashes, but often of rocky fragments of great size.

These, by their mutual friction, as they alternately fall back and are thrown up again, become, as has already been said, greatly comminuted; and the source of the explosive vapors having sooner or later exhausted its energies, the accumulation of these ashes in the vent at length appears to stifle their further development, and quiescence for a time ensues. [I am speaking here, of course, of the case of such a paroxysmal eruption as I had the advantage of witnessing in 1822.]

I have said that every crater is more or less circular in figure; but, since the orifice of discharge will almost necessarily be opened on the least resisting point of some fissure broken through the solid preëxisting rocks, we might expect its section to be often lengthened in the direction of this fissure, and consequently to be rather oval than strictly circular. And this expectation is justified by observation. Sometimes two orifices have been opened upon the same fissure so near together that their craters or cones intersect each other. In the range of Puys of Auvergne and the Velay such examples are frequent. And in the eruption of 1850 of Vesuvius two craters were formed on the summit of the cone divided only by a narrow ridge; their common horizontal axis coinciding with the line of the great fissure, which in the preceding year had been visibly broken through the side of the cone towards the northeast. Sometimes

aëriform explosions take place from openings upon lateral fissures, and produce those minor, or (as they are often called) parasitic cones, of which several examples occur on the flanks both of Vesuvius and Etna. At other times, the explosions are confined to the central vent of the volcano, the lava alone welling out, perhaps, at some lateral orifice. This, indeed, is the normal character of these phenomena. And it is this habitual predilection (as it may be called) of volcanic eruptions for the same identical vent, that occasions in so many instances the heaping up of some vast mountain mass above and around it, subject to the occasional blowing up of the central portion, to be re-formed again and again by subsequent eruptions. The result of the irregular alternation of these paroxysmal explosions and subsequent gradual expulsions of new matter is the appearance, so common in volcanic mountains, of a minor and central cone with its crater, rising within the circumference of some larger crater of earlier date, or in its immediate vicinity. The walls of the latter crater are of course often broken down on one or more sides (generally on the line of the original fissure); —perhaps reduced to a mere segment of its original circuit, by the combined operations of volcanic convulsions and aqueous erosions. Whoever will take the trouble to examine carefully an accurate map, on a sufficiently large scale, of almost any volcanic district (such, for example, as Vesuvius and the Phlegræan Fields, Etna and the Lipari Isles, the Roman Territory, the Grecian Archipelago, Madeira, Teneriffe, the Azores, Bourbon, St. Helena, Barren Island, the Leeward Isles, &c.), will see numerous unquestionable examples of this law by which crater is formed within crater, and new cones upon the ruins of old ones.

History of Vesuvius.—At the risk of repetition, I must be permitted to illustrate this law by the trite, but instructive, example of Vesuvius,—which only comes so often before us because from its proximity to Naples it has been open to more constant and accurate observations than any other known volcanic mountain. What, in brief, is the history of this volcano during the last century? Precisely one hundred years ago, in the year 1756, Vesuvius possessed no less than three cones and craters, one within the other, like a nest of boxes, besides the great encircling crater and cone of Somma (fig. 1). Sir W. Hamilton gives us a drawing of its appearance in this state.

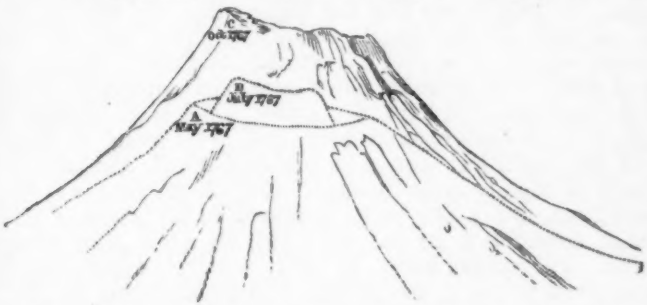
By the beginning of the year 1767, the continuance of moderate eruptions had obliterated the inmost cone and increased the intermediate one, until it very nearly filled the principal crater (fig. 2, A, B). An eruption in October of that year, 1767, completed the process, and re-formed the single cone into one continuous slope all round from the apex downwards (fig. 2, C). The dotted lines in fig. 2 (after Hamilton) represent the shape of

Fig. 1.—*Outline-sketch of Vesuvius as it existed in* 1756.

a. Somma.

the outer and inner cones before this eruption, and the space between them and the firm outline represents the amount by which the cone was in the intervening ten years augmented in bulk and height by the ejectamenta of that eruption. An interval of comparative tranquillity followed, until, in 1794, the paroxysmal

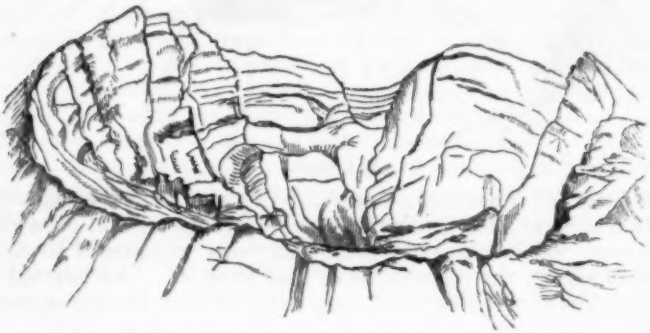
Fig. 2.—*Outline-sketch of Vesuvius as it appeared in October,* 1767; *with dotted outlines of its form in July and in May of the same year.*



eruption occurred, described by Breislak, which completely gutted this cone, then solid, lowered its height, and left a crater of great size bored through its axis. Later eruptions, especially that of 1813, not merely filled up this vast cavity with their products, but once more raised the height of the cone by some hundred feet. When I first saw it in 1819 the top formed a rudely convex platform, rising towards the south, where was its highest point. Several small cones and craters of eruption were in quiet activity upon this plain, and streams of lava trickled from them down the outer slopes of the cone. So things went on until October, 1822, when the entire heart of the cone was again thrown out by the formidable explosions I have so often referred to, and a vast crater was opened through it; while the cone itself was found to have lost several hundred feet from its

top. In fact, nothing but an outer shell of it was left (fig. 3). Eruptions, however, soon recommenced. In 1826–7 a small cone was formed at the bottom of the crater, and, continuing in activity, had reached a height which rendered it visible from

Fig. 3.—*Crater of Vesuvius after the Eruption of October*, 1822.



Naples in 1829, when of course it must have nearly filled up the crater. In 1830 it was 200 feet higher than the crater's rim; and in 1831 this cavity was completely filled, and the lava-streams began to flow over it down the outer cone. In the winter of that year a violent eruption once more emptied the bowels of the mountain, and left a new crater, which soon began to fill again from ejections upon its floor; and by the month of August 1834, this crater had been in its turn obliterated, and lava overflowed its edge towards Ottaiano. In 1839 the cone was again cleared out, and a new crater appeared in the shape of a vast funnel, accessible to its bottom, which for a few years then remained in a tranquil state. In 1841, however, a small cone began to form within it, and increased so rapidly, that in 1845 it was visible from Naples above the brim of the crater, which soon after was completely filled. And the cone from that time went on increasing in bulk and height from the effect of minor eruptions, until in 1850 one of a violently explosive character opened the two deep craters on its summit, of which I have already spoken. The more recent eruption of May last, being confined chiefly to a prodigious efflux of lava from the outer side of the cone, unaccompanied by any extraordinary explosive bursts from the summit, has not altered materially the form impressed upon it in 1850.

It is thus seen that within the last 100 years the cone of Vesuvius has been five several times gutted by explosive eruptions of a paroxysmal character, viz., in 1794, 1822, 1831, 1839, and 1850; and its central craters formed in this manner as often gradually refilled with matter, to be again in due time blown

into the air. Meanwhile the old external crater of Somma is itself becoming choked up by the accumulation of all the lava-streams and fragmentary matter that are expelled towards the northern and outer side of the cone. It would be, therefore, in exact accordance with the habit of this volcano (as of volcanic mountains in general), if, after some further period either of quiescence or of moderate activity, the entire cone of Vesuvius should be blown up by a more than ordinarily violent paroxysm, and the crater of Somma itself reformed.

With this well-authenticated history of the mountain within our knowledge, would it not be wholly unphilosophical to deny (except upon such grounds of impossibility as have never been adduced) that the larger containing crater in the case of Vesuvius (and the argument applies to other similar volcanic mountains) had the same origin as the smaller contained ones; and that the external cones were produced in the same manner as the internal, and similarly constituted ones? And therefore those who refuse to believe the former to be of eruptive origin must be prepared to extend their incredulity to the latter. Indeed the elevation-crater theorists usually do not shrink from this consequence. With them the cone of Vesuvius, and that of Monte Nuovo itself, were not the products of eruption, but of elevatory expansion by a single shock. Obviously, it ought to follow, that no volcanic mountain was ever in eruption at all, that the whole is an ocular illusion; at least, that the lava-streams we see pouring for weeks and months from the summit of a cone and hardening there, and the enormous showers of fragmentary matter which, during equally long periods, we see thrown up from the crater and falling on the surface of the cone, do not, even in the lapse of ages, add to its bulk or tend by their frequent repetition to compose the substance of a volcanic mountain, but, by some unaccountable process, disappear without leaving a trace behind. I own that, to my mind, such an hypothesis is wholly unintelligible. I see in the ordinary phenomena of a volcanic mountain, such as I have described them in the brief record of the principal eruptions of Vesuvius during the last century, a simple and natural process by which such a mountain is gradually built up; and, having observed this mode of formation going on in some instances before my eyes, I think it reasonable to apply it to explain the mode of formation of other mountains of the same class, with their cones and craters, old and new, central and lateral, or parasitic; and making allowance, as I said at first, for a certain amount of internal accretion and elevation, by means of intrusive dykes and earthquake shocks, I know nothing in the appearance, figure, or structure of any volcanic mountain yet discovered, which such an ordinary and observed mode of formation will not account for.

(*To be concluded.*)

ART. XXXVI.—*On the Climate of Iowa: embracing the result of Meteorological Records of the year* 1856, *at Muscatine, Iowa, with a Synopsis of the records of the seven years from* 1850 *to* 1856, *inclusive;* by T. S. PARVIN, of Muscatine.

1. *Meteorological Journal, for the year* 1856.*

1856.	Barometer. H't reduced to freez'g p'nt.				Thermometer in the open air.					Force of Vapor, in inches.			Relative Humidity.		
Months.	7 A. M.	2 P. M.	9 P. M.	Monthly Mean.	7 A. M.	2 P. M.	9 P. M.	Monthly Mean.	Maximum.	Minimum.	7 A. M.	2 P. M.	9 P. M.	7 A. M.	2 P. M.	9 P. M.
	Inch.	Inch	Inch.	Inch.	°	°	°	°	°	°	Inch.	Inch	Inch.			
January,	29·62	29·59	29·59	29·60	2·1	14·8	5·8	7·52	26	-26	·049	·099	·057	84	84	83
February,*	29·42	29·41	29·44	29·42	10·1	22·2	12·8	15·03	42	-29	·072	·126	·079	76	82	80
March,	29·53	29·51	29·53	29·54	19·8	34·2	24·2	25·80	56	-17	·085	·164	·101	69	77	72
April,	29·35	29·34	29·35	29·34	43·9	59·8	48·6	49·37	77	27	·241	·426	·275	75	78	76
May,	29·39	29·38	29·38	29·38	54·5	70·2	59·1	61·38	90	40	·334	·437	·386	78	63	77
June,	29·38	29·33	29·36	29·35	65·1	79·8	66·4	71·79	97	50	·565	·712	·593	81	58	81
July,	29·41	29·40	29·41	29·43	67·7	81·1	69·9	73·51	93	55	·630	·941	·697	90	69	90
August,	29·45	29·42	29·42	29·43	57·3	77·9	60·9	65·40	91	40	·469	·671	·503	90	63	87
September,	29·45	29·44	29·43	29·45	50·1	71·1	56 5	59·00	91	28	·362	·492	·430	89	55	82
October,	29·54	29·50	29·49	29·51	44·4	61·5	51·7	52 85	82	25	·294	·405	·347	64	67	81
November,	29·29	39·31	29·32	29·34	28·1	38·8	32·1	32 79	54	4	·139	·189	·153	79	76	83
December,	29·53	29·50	29·53	29·52	11·5	20·0	14·2	15 63	42	-13	·077	·107	081	82	85	81
Sums,	353·36	353·13	353·25	353·29	450·6	631·6	502·9	530·04	841	184	3 317	4·830	3·072	956	857	973
Means,	29·44	29·43	29·43	29·44	37·5	52·6	41·9	44·17	70	15	·276	·402	·308	79	71	81

* The Barometrical record for January and February is the "Observed Height."

2. *Clouds, Rains, Winds, &c.*

1856.	Clouds; Amount, Course and Velocity. Amount from 10 to 0: velocity from 0 to 10						Weather—Rain and Snow. Days and amount.						Winds. Direction.			
Months.	7 A. M.	2 P. M.	9 P. M.	N. E. — S. E.	S. W. — N. W.		7 A. M.	2 P. M.	9 P. M.	Clear.	Cloudy.	Variable.	No. days.	Amount in inches.	No. days.	Depth—inches.	N. E. — S. E.	S. W. — N. W.
January,	4·1	3·3	2·6		2		2	1·3	1 3		16	7	8		4	12·2	3	6	6	16
February,	6·4	5·0	4·4	1			3	4	2·3	2·6	1·3		5	4	20	1	4·34	7	12·0	6	1	11	11
March,	2·7	4·0	4·0	1		10	9	2·0	2 2	2·0			9	2	20	1	·25	6	3·6	2	2	11	16
April,	4·5	5·5	2·3	2	3	13	7	2·2	2·0	2·3			4	6	20	4	3·44			3	10	11	6
May,	3·7	4·8	4·4	3	3	6	7	2·0	2·0	1·4			9	6	16	12	4·39			6	9	8	8
June,	1·7	2·8	2·5	3	1	12	1	2·4	1·8	2·0			10	2	18	4	2·68			5	8	12	5
July,	2·5	2·4	1·9	1	5	15	2	1·9	1·4	1·5			15	2	14	9	2·74			3	10	9	9
August,	3·1	3·3	1·1	1	1	11	10	1·2	2·0	1·5			12	5	14	3	1·36			4	6	12	9
September,	3·3	3·4	2·8		3	13	11	2·2	2·3	1·7			13	5	12	3	2·45			1	6	12	11
October,	5·4	5·0	3·4	2	3	8	5	2·0	2·0	2·0			8	8	15	7	5·21			3	13	10	5
November,	5·9	6·1	5·4	2	1	12	3	2·0	2·0	2·0			6	11	13	10	3·83	2	5·2	3	6	7	14
December,	5·9	4·5	3·9	2	2	3	3	2·3	2·0	2·0			6	11	14	8	6·06	5	19·0	7	6	2	16
Sums,	49·2	50·1	38·7	18	22	108	64	23·8	23 6	19·7			113	69	184	60	36·74	24	52·0	47	83	111	126
Means,	4·1	4·2	3·2	1	2	9	5	1·9	1·9	1 6			9	6	15	5	3 06	5	10·2	4	7	9	10

Force of Winds at 7 A. M., 2 P. M. *and* 9 P. M.—*Force from* 0 *to* 10.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Sums.	Mns.
7 A. M.	1·5	1·5	1·7	2·1	1·7	1·5	1·4	1·2	1·7	1·4	1·5	1·8	19·0	1·7
2 P. M.	1·8	1·9	2·2	2·3	2·0	2·1	1·5	1·9	2·5	1·8	1·8	1·9	23·7	1·9
9 P. M.	1·6	1·4	1·7	1·7	1·7	1·4	1·1	1·1	1·5	1·5	1·7	1·9	18·2	1·5

* Latitude of Muscatine 41° 25′ North; Longitude 92° 2′ West, (proximate). Barometer 72·21 feet above low water in (and 586·21 feet above the mouth of) the Mississippi River.

3. *Miscellaneous Remarks*, 1856.

Lowest temperature, February 4, −29°	Mean temperature, - - - 44°·1
Highest " June 24, 97°	Average mean for 18 years, - 47°·12
Range of " - - - 126°	[Range 43°·21, 1849; 50°, 1846.]
Lowest height barom'r, Nov. 21, 28·80 inch: therm. attached, - - 37°	Range of barometer, - - 1·20 inch.
Greatest height barom., Jan. 25, 30·00 inch: therm. attached, - - 15°	Mean height " - - - 29·44 "
Frost last in the Spring, - April 19	Depth of ground frozen, - 2 ft. 6 in.
Frost first in the Fall, - Sept. 24	Thickness of ice on the river, 2 ft. 3 in.
Disappearance of frost from gr'nd, May 1	

Flowering of Fruit Trees.—Apple, May 12; Cherry, May 9; Peach;* Plum, May 12; Pear, May 15; Quince.*

Total quantity of rain in inches, 36·74 in.; in 1855, 24·55 in.; least 1854, 21·1 in.; greatest 1851, 72·4; mean, 41·90 in.

January and February.—Intensely cold; began to moderate about the 20th of February. *March and April.*—River high; Spring very backward; Peach and Quince trees all killed, and Pear, Cherry and Plum trees badly injured; the Apple also considerably injured. *August, September and October.*—River extremely low; weather dry until the middle of October. *November.*—Very wet; River good stage. *December.*—Very rainy and changeable; more snow than for many winters.

River Statistics.

Mississippi closed, Dec. 6. In 1855, Dec. 25	The greatest rise, May, - 13 ft. 3 in.
" opened, March 29.	" " fall, September, 8 ft. 10 in.
No. of days closed, 94, double that of 1855.	Extreme rise and fall, - 4 ft. 5 in.
Earliest closing (*in 20 years*), Nov. 26, 1842.	Earliest time of closing, Jan. 29, 1846.
Latest " Jan. 29, 1850.	Latest " " April 8, 1843.
Average " December 31.	Average " " March 1.
Shortest period Mississippi closed, 22 days, in 1850–'51.	Longest period Mississippi closed, 133 days, in 1842–'43.
Average period Mississippi closed, 60 days.	

Mean Temperature of each of the Months and the Seasons for the years 1850–1856; *also of each for seven years, with the difference between the means of the year* 1856 *and those of the whole period of seven years.*

Months and Seasons.	Years—Temperature.							Means.	Diff. 1856
	1850	1851	1852	1853	1854	1855	1856	7 years.	and mean.
	°	°	°	°	°	°	°	°	°
December, 1849, ...	18·34	19·77	21·37	22·18	26·67	26·76	22·40	22·49	− 6·86
January, ...	24·40	23·97	19·60	27·05	16·16	24·46	7·52	20·45	−12·93
February, ...	26·85	27·73	29·00	23·36	28·50	15·64	15·03	23·73	− 8·70
Winter mean, ...	23·19	23·82	23·32	24·19	23·77	22·28	14·98	22·22	− 7·24
March, ...	32·60	38·22	36·15	33·24	39·86	30·51	25·80	33·77	− 7·97
April, ...	41·22	43·52	42·74	47·81	51·13	53·93	49·37	47·10	+ 2·27
May, ...	53·30	58·19	59·96	55·65	60·03	60·42	61·38	58·42	+ 2·96
Spring mean, ...	42·56	46·64	46·28	45·56	50·00	48·28	45·51	46·40	− ·81
June, ...	70·17	64·64	66·80	71·22	68·96	67·02	71·79	68·65	+ 3·04
July, ...	74·22	71·62	72·36	68·82	76·16	73·01	73·51	72·81	+ ·70
August, ...	72·22	69·09	68·98	71·08	73·00	70·35	65·40	70·01	− 5·61
Summer mean, ...	72·20	68·45	69·38	70·37	72·37	70·16	70·23	70·44	− ·21
September, ...	59·83	68·34	59·76	62·21	68·23	67·92	59·00	63·61	− 4·61
October, ...	44·15	50·35	53·18	45·46	54·36	47·14	52·85	49·67	+ 3·18
November, ...	37·55	34·50	30·00	39·73	36·83	37·85	32·79	35·60	− 2·81
Autumn mean, ...	47·17	47·73	47·64	49·13	53·13	50·96	48·21	49·14	− ·93
Annual mean, ...	46·28	46·66	46·65	47·31	49·81	47·92	44·73	47·05	− 2·52

* All killed in this region by the severe cold of last winter.

Total quantity (in inches,) of Rain of each of the Months and Seasons for the years 1850–'56; also, the mean of each for seven years, with the difference between the total of the year 1856 and the mean of the septennial period.

Months and Seasons.	Years—Rain.							Means 7 ye'rs.	Diff. 1856 and me'n.
	1850.	1851.	1852.	1853.	1854.	1855.	1856.		
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
December, ...	·40	2·50	1·90	5·00	....	·41	2·02	1·75	+ 4·30
January, ...	4·40	1·50	2·20	·30	....	1·50	....	1·41	– 1·41
February, ...	·80	4·50	1·00	·70	1·25	.....	4·34	1·79	+ 2·55
Winter total, ...	5·60	8·50	5·10	6·00	1·25	1·91	6·36	4·96	+ 1·40
" mean, ...	1·87	2·83	1·70	2·00	·42	·63	2·12	1·65	+ ·47
March, ...	2·00	3·00	8 60	·70	1·12	1·22	·25	2·41	– 2·16
April, ...	3·30	3 60	5·30	11·80	1·76	2·55	3·44	4·54	– 1·10
May, ...	3·70	12·60	6·50	4·60	6·21	1·94	4·39	5·70	– 1·31
Spring total, ...	9·00	19·20	20·40	17·10	9·09	5·71	8·08	12·65	– 4·57
" mean, ...	3·00	6·40	6·80	5·37	3·03	1·87	2·69	4 16	– 1·47
June, ...	3·50	14·30	2·20	6·40	·66	4·75	2·68	4·92	– 2·24
July, ...	5·00	8·60	3·70	6·60	2·22	2·35	2·74	4·45	– 1·71
August, ...	13·00	14·00	2·80	1·70	3·33	3·51	1·36	5·66	– 4·30
Summer total, ...	21·50	36·90	8·70	14·70	6·21	10·61	6·78	17·05	– 10·27
" mean, ...	7·16	12·30	2·90	4·90	2·07	3·53	2·26	5·01	– 2·75
September, ...	3·90	3·50	8·30	6·20	1·13	1·84	2·45	3·90	– 1·45
October, ...	2·70	1·40	7·60	·20	4·29	2·81	5·21	3·45	+ 1·76
November, ...	3·50	3·50	5·50	4·10	·09	2·08	3 83	3·23	+ ·60
Autumn total, ...	10·10	8·40	21·40	10·50	5·51	6·73	11·49	10·59	+ ·90
" mean, ...	3·36	2·80	7·13	3·50	1·81	2·24	3·83	3·52	+ ·31
Annual total, ...	46·20	73·00	55·60	48·30	22·06	24·96	32·71	43·26	– 10·55
" mean, ...	3·93	6·08	4·63	4·02	1·84	2·08	2·72	3·44	– ·72

Total quantity of Snow (in inches) of the Months and Seasons of Snow, for the years 1850–56; also the means of each for seven years, with the difference between the total of '56 and the means of the septennial period.

Months and Seasons.	Years—Snow.							Means 7 y'rs.	Diff. bet. '56 and mean.
	1850.	1851.	1852.	1853.	1854.	1855.	1856.		
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
December ('49), ...	4·70	3·70	1·50	11·40	3·20	1·00	13·00	5·50	+ 7·50
January, ...	2·20	·50	3·20	1·00	4·00	17·50	12·20	5·80	+ 6·40
February, ...	....	8·40	....	2·00	5·50	7·10	12·00	5·00	+ 7·00
Winter total, ...	6·90	12·60	4·70	14·40	12·70	25·60	37·20	16·36	+20·84
" mean, ...	2·30	4·20	1·56	4·80	4·25	8·86	12·40	5·48	+ 5·82
March, ...	·80	·30	....	2·00	1·10	6·50	3·60	2·04	+ 1·56
April, ...	·20	6·00	....	....	....	....	....	....	
November, ...	·90	1·30	2·60	8·00	1·00	1·50	5·20	2·93	+ 2·27
Annual total, ...	8·80	20·20	7·30	24·40	14·70	33·60	46·00	22·14	+23·86
" mean, ...	1·40	3·36	1·21	4.06	2·45	5·60	7·66	3·68	+ 3·98

Time of first and last Frosts and formation of Ice, for the years 1850–1856, *with the average period of each.*

Frost and Ice.	Years.							Mean Time.
	1850.	1851.	1852.	1853.	1854.	1855.	1856.	
Frost first, ..	Sept. 7	Sept. 28	Sept. 26	Sept. 10	Oct. 15	Sept. 27	Sept. 24	Sep. 24
" last,...	April 23	May 5	May 20	May 25	May 2	May 6	April 19	May 6
Ice first, ...	Sept. 29	Oct. 15	Sept. 26	Oct. 2	Oct. 15	Oct. 25	Sept. 24	Oct. 7
" last, ...	April 23	May 1	April 22	May 13	May 2	May 6	April 19	Apr. 29

Period of the Flowering of Fruit Trees, for the years 1850–56, *with the average period of each.*

Varieties.	Years.							Mean Time.
	1850.	1851.	1852.	1853.	1854.	1855.	1856.	
Apple, ...	May 3	May 3	May 10	May 4	Apr. 24	Apr. 29	May 12	May 3
Peach, ...	" 1	" 1	" 10	Apr. 30	" 20	May 1		" 1
Cherry, ...	" 1	" 1	" 5	May 1	" 22	" 1	May 9	" 1
Plum, ...		Apr. 29	" 1	" 3	" 21	" 10	" 12	" 8
Pear, ...			" 5	" 3	" 20	" 1	" 15	" 9
Quince, ...				" 5	" 24	" 10		" 13

Additional Remarks.

Year. *Temperature.*—The mean temperature of the year at this point for *seven* years past is 47·05 degrees, while that of the past year is only 44·73, or 2·32 less than the septennial average, and is the coldest year of the seven; the range being from 46·28°, in 1850, to 49·81°, in 1854. The winter was intensely cold, all the months ranging below the corresponding means, while the first spring month, the last summer month, and the first and last autumn months, were also below the corresponding means of those months.

The river did not open until the 29th of March, four weeks after the average period of its opening, and the spring was very late. The severe winter had killed all the peach, plum, and quince trees in this region, and about three-fourths of the pear, and nearly one-fourth of the apple trees were seriously injured or entirely killed by the low temperature.

Rain.—The total quantity of rain and melted snow for the year is 32·71 inches, (the discrepancy between this number and the footing in the first table arises from the fact that in that the legal year is accounted, and in this the astronomical year is recorded, and throughout the table of "Rain" and "Snow" December of '49 is counted and December of '56 omitted), being 10·55 inches less than the septennial mean of 43·26 inches. The annual range in quantity has been very great, from 22·06 inches in 1854, to 73·00 inches in 1851. It was in this latter year that the high water occurred in the Mississippi and its tributaries—the highest known to that mysterious person, "the oldest inhabit-

ant." In 1854 occurred the "great drought" in this and the Western States generally, but owing to the porous nature of our soil, the crops with us turned out much better than in States east of the Mississippi.

Snow.—The total quantity of snow for the year ('56) is 46 inches, or 23·86 more than the mean. The smallest amount was in 1852, only 7·30 inches, while for the past two years the amount has greatly increased, and it is owing to the item of melted snow (ten inches of snow when melted making one inch of water) of the past and previous year that the amount of rain has been as large as it is, for the summer was very dry.

WINTER. *Temperature.*—The mean temperature of the winter is 7·24° below the average, the former being 14·98°, that of the latter 22·22°. The warmest winter was that of 1853, 24·19°. The coldest of twenty was that of 1855–56, when for days together the thermometer ranged below zero, sinking as low as -29°. Each of the winter months are below the mean. The prevailing winds are west and northwest.

Rain.—The quantity of rain including melted snow, is for '56 greater than the mean, but without it, less. In the winter of '54 there was no rain in December or January, in that of '55 none in February, and none in January of the past winter ('56). Total of rain and melted snow is 6·36 inches; the mean is 4·96 inches.

Snow.—The average depth of snow is 16·36 inches, while in the winter of 1855–56 we had 37·20 inches, exceeding the mean by 20·84 inches. In 1851–52 there were but 4·70 inches, which had steadily increased in the succeeding four years.

SPRING. *Temperature.*—The mean temperature is 45·51°, being only ·81° below the mean, which is 46·40°. The coldest spring was in 1850, the mean being 42·56°; the warmest was 1854, 50·00°. The temperature of the spring months of the past year was unequally distributed, March being much below the mean, while April and May were above.

Rain.—Each of the months was below the mean in quantity of rain, the total being 8·08 inches, and the mean 12·65 inches.

Snow.—There has been snow in March of each year, except that of 1852, and in 1850 and '51 there was snow in April. The total for March '56 was 3·60 inches, and the mean 2·04 inches.

The prevailing winds of the spring months are for March west and northwest; April south and southwest, and May east and southeast.

SUMMER. *Temperature.*—There was less than a degree difference between the temperature of this summer and the mean of the last seven years, the former being 70·23°, and the latter 70·44°. July is the warmest month. The summer temperature

ranges from 68·45 in 1851, to 72·37° in 1854. From this comparison the past summer was neither too hot nor too cold.

Rain.—This season was very dry. The total quantity of rain was only 6·78 inches, while the mean reaches 17·05 inches, an excess over the last season of 10·27 inches.

The crops, were, notwithstanding the summer drought, more than an average yield both of corn and small grain, and the three or four dry seasons we have had has abundantly proved that the soil and climate of Iowa are unsurpassed on the continent for farming purposes.

The prevailing winds are southeast and southwest.

AUTUMN. *Temperature.*—The temperature of this season, too, was quite uniform, being less than a degree below the mean. September was colder than the mean by 4°, and there were several frosts this month which shortened the corn crop somewhat.

Rain.—September and the first half of October were very dry, but in the middle of the latter month the rains set in, and the latter half of October and the whole of November were unusually wet, exceeding the mean by near an inch. The total is 11·49 inches, and the mean 10·59 inches.

Snow.—In every year we have had snow in November; in 1856, 5·20 inches, mean 2·93 inches, an excess therefore of 2·27 inches.

In this and for several years past we have had no "January thaw," and during this year as well as the previous one, we had no "June rise." Notwithstanding the deep snows here and farther north, the river had only a moderate stage of water in the spring, and during the summer and autumn it was very low, so low as to prevent the passage of boats over the Rapids for months.

The prevailing winds are south and southwest.

January.—The mean temperature of this month for the past year was 7·52°; that of the seven years past, 20·45°. The coldest January was the past; (the lowest range of the thermometer in seven years was −29°, Feb. 4, '56;) the warmest in 1853, 27·05°. This is the coldest month of sixteen years. In '54 and '56 there was no rain, in 1850 there was 4·40 inches, the mean being 1·41 inches.

In 1851 there was but ·50 inch of snow, while in 1855 there were 17·50 inches, in '56 12·20 inches; the mean is 5·80 inches.

River low and closed all the month.

February.—The mean temperature for the year is 15·03, for the seven years, 23·73; that of 1856 being 8·70 below the mean, and the coldest February for seven years past; the warmest was that of 1852, the mean being 29·00.

The amount of rain for this month, including melted snow, is 4·34 inches; in 1851 it reached to 4·50 inches, and in 1855

there was none; the mean is 1·79, showing an excess for the last February of 2·55 inches.

In 1850 and 1852 there was no snow in February, while in 1856 there fell 12·00 inches, the mean being only 5·00 inches.

The River low and closed.

Prevailing winds in January and February, northwest and west.

March.—The most unpleasant month of the year, characterized in this region, by high, chilly winds, from a western direction. The frost which usually penetrates to a depth of from 20 to 25 inches, as it escapes, leaves the earth soft and wet, and the roads are soon cut up by the travel and rendered almost impassable.

The mean temperature of this month in 1856, is 25·80° or 7·97 less than the mean, which is 33·77°. This month of the past year, like the two preceding, is the coldest of the past seven years. In 1854 the mean temperature was 39·86°.

There was but little rain in March, only ·25 inch, the mean being 2·61 inches, and maximum 8·60, in 1852.

Snow has fallen every year in March, except 1852, the maximum being in 1855, 6·50 inches; the mean is 2·04 inches, while in the last March, there were 3·60 inches.

The Mississippi River opened on the 29th, having been closed ninety-four days; the average period of its opening for twenty years past is the first of March, and the average length of time closed is sixty days. River still low.

April.—This is *practically* in this climate the first spring month, as the winter "drags its slow length along" so far into its predecessor that but little out-door work can be done. The range of its mean temperature is from 41·22°, in 1850, to 53·93°, in 1855, that of 1856 being 49·37°, or 2·27 above the mean of 47·10°. In this month the fruit trees generally put forth their blossoms. and the birds of song make their welcome return.

In April 1850–51 there fell snow, in the latter year to the depth of 6·00 inches. The mean total of rain is 4·54 inches; that of '56 being 3·44 inches, or 1·10 less than the mean. The range is from 1·76, in 1854, the dry season, to 11·80, in 1853.

The melting snow did not materially raise the river, which continued at a low stage.

It was now that an inspection of the fruit trees showed how severe was the injury inflicted upon them by the past winter. The wood, which preserved its natural color, revealed by the incision of the pruning knife an entire absence of sap and vitality; even the forest trees were split open in many cases by the action of the frost.

May.—This and October are the most pleasant and delightful months of the year.

All the previous months of the year have revealed a temperature below the mean, that of this month is above by 2·96°, the mean being 61·38°, the highest in seven years, while that of the seven is but 58·42°; the lowest was in 1850, being 53·30°.

The total of rain is 4·39 inches; the mean of seven years 5·70, the maximum, in 1851, the year of highest water, 12·60 inches; the minimum, in 1855, 1·94 inches.

A gradual rise in the river, and a good stage of water.

June.—This month too shows a mean temperature (of 3·04°) above the average, the first being 71·79°, and the latter 68·65°, and was the warmest June in seven years; the coldest was in 1851, 64·64°.

The quantity of rain in this month is 2·68 inches, the mean 4·92. The greatest was 14·20 inches, in 1851, and the least in 1856, only ·66 inch.

The river at a good stage, but without the June rise; there was none in 1854 or '55, while in 1853 it came nearly up to the high water mark of '51.

July.—This is the hottest month of the year, the mean temperature being 72·81°; that of the coldest month (January) is 20·45°. The annual mean is 47·05°. The warmest month then exceeds the annual mean by 25·76°, and the coldest falls short 26·60°.

The mean for the last year is 73·51°, an excess of ·70 above the mean, the greatest of which is for 1855, 76·16°, and the least the year preceding, 68·82°. The highest range of the thermometer in seven years is 99°, August 31; range 128°.

The mean amount of rain for this month is 4·45 inches, the total for July 1856, 2·74 inches, and the range from 2·22 inches to 8·60 inches in the years 1854 and 1851, the dry and wet years of the seven, and indeed of the last nineteen (of our record.)

The river fell several inches during the month, and continued at a low stage, almost suspending navigation for this and the two succeeding months.

August.—This month for the past year was colder than in any of the preceding seven, its mean temperature being 65·40°, while the average mean is 70·01, and the greatest was in 1854, when it was 73·00°. It was very dry, notwithstanding its low temperature, the total of rain being only 1·36 inches, the least of the seven, the greatest (as before) being in 1851, 14·00 inches, and the mean 5·06 inches.

The health of the summer was good; in fact, a more healthy region or climate is scarcely to be found.

September.—This month, too, is below the average mean in its temperature, 4·61°, and like last August is the coldest of the seven years. Its mean temperature is 59·00°, the average 63·61°, and the maximum mean that of 1851, 68·34°. Occasionally

frosts occur in the early part of this month, to the injury of the corn crop, which was the case partially last year.

The average amount of rain is 3·90 inches, and the total in September last, 2·45 inches, which amount was increased in 1852 to 8·30 inches, and diminished to 1·13 inches in 1853.

October.—The Autumns are always delightful in the region round about Iowa, and this is the pleasantest of its months. The mean temperature of this month differs from that of the season by being only ·53° greater, and exceeds that of the year 1·99° only; while April approximates to within ·05° of it.

The mean temperature is 49·67°, while the range is from 44·15 to 54·36°, in the years 1850 and '54 respectively.

The amount of rain in this month is 5·21 inches; the mean 3·45 inches. In 1850 there was only ·20 inch, and the greatest was the last year, when the latter part was very wet.

The river rose several inches in the latter part of this month.

November.—This is the last month of the *physical* year, and closes the autumn or fall season. The mean temperature for 1856 is 32·79°, and the average mean 35·60°. The consecutive years of 1852–53 furnish the extremes of means, the first being 30·00 and the last 39·73°.

This month was very wet, and more disagreeable than any for several years past, showing an entire absence of our usual "Indian Summers." The mean amount of rain is for November 3·23 inches, the total for 1856, 3·83 inches, an excess of ·60 inch. In 1854 the amount was only ·09 inch, and in 1852 it was 5·50 inches.

December.—In our tables, extending over the period of seven years, we have included December 1849 and excluded it for 1856.

The mean temperature, however, of this month for this latter year is less than any of the preceding, being only 15·63, 6·86 less than the mean, which is 22·49°, the maximum being in 1854, 26·76°.

In December, 1853, there was no rain; in the preceding year the amount was 5·00 inches; in the last December it reached 6·05 inches, while the mean is only 1·75 inches, showing an excess of 4·30 inches.

The average period of the closing of the River (Mississippi) is the 31st of this month; this year it closed suddenly on the night of the 6th, with a low stage of water.

ART. XXXVII.—*Statistics of the Flora of the Northern United States;* by ASA GRAY.

[Continued from p. 84.]

ALTHOUGH such details as I have to present are far from inviting to general readers, it is desirable to put them upon record, inasmuch as the facts they bring to view are useful to those philosophical naturalists who are discussing important problems respecting the present distribution of plants and animals over the world, and the causes which have determined the present state of things. This must be my excuse for continuing at such a length the present series of articles.

Having compared our flora with that of Europe in respect to closely allied species, it may be interesting to institute a similar comparison with that of Oregon and Northern California. The comparison might also be extended to Northwestern Asia, and especially to Japan, with which we have peculiarly interesting relations as to species; but this is better deferred until some recent collections from the northern part of Japan have been completely examined.

Comparison of the Flora of the Northern United States with that of the Pacific coast of North America (Oregon and North California) between lat. 46° and lat. 36°.

1. *As to Geographical Varieties.*

The following have been distinguished as species by excellent botanists, but in most cases, perhaps in all, they should rather be considered geographical varieties.

Natives of Eastern N. U. S.	*Natives of Oregon and California, lat. 46°–36°.*
Trautvetteria palmata,	T. grandis, *Nutt.*
Aquilegia Canadensis,	A. formosa, *Fisch.*
Actæa spicata,	A. arguta, *Nutt.*
Erysimum Arkansanum,	E. asperum and elatum, *Nutt.*
Honkenya peploides,	H. oblongifolia, *Torr. & Gr.*
Stellaria borealis,	S. crispa, *Cham.*
Euonymos atropurpureus,	E. occidentalis, *Nutt.*
Negundo aceroides,	N. Californicum, *Torr. & Gr.*
Vicia Americana,	V. Oregana, *Nutt.*
Astragalus Canadensis,	A. orthocarpus, *Dougl.*
Spiræa opulifolia,	S. capitata, *Pursh*, S. pauciflora, *Nutt.*
" Aruncus,	S. acuminata, *Dougl.*
Potentilla Pennsylvanica,	P. Hippiana, pulcherrima, bipinnatifida, &c.
Rubus Nutkanus (parviflorus, *Nutt.*),	R. Nutkanus,

Rubus occidentalis,	R. leucodermis, *Dougl.*
Rosa blanda,	R. fraxinifolia, *Lindl.*
Amelanchier Canadensis,	A. alnifolia, *Nutt.*
Heracleum lanatum,	H. Douglasii, *DC.*
Osmorrhiza brevistylis,	O. divaricata, *Nutt., &c.*
Sambucus Canadensis,	S. glauca, *Nutt.*
Galium boreale,	G. rubioides, *Linn.*
Chrysopsis villosa,	C. echioides, *Benth.*
Menziesia ferruginea, var. globularis,	M. ferruginea, *Smith.*
Pyrola rotundifolia,	P. bracteata, &c., *Hook.*
Plantago maritima, juncoides,	P. maritima.
Taxus baccata, var. Canadensis,	T. occidentalis, *Nutt.*
Xerophyllum setifolium,	X. tenax, *Pursh.*
Luzula campestris,	L. comosa, *Meyer.*

2. *Strictly Representative Species.*

The following are cases of species of our Flora of the Northern United States represented on the western side of the continent by *strictly representative species,* (including very *close representative species,*) many of which, although still admitted as distinct, are not unlikely to be regarded hereafter as geographical varieties. The very close representative species are printed in *italics.*

Natives of Eastern N. U. S.	*Natives of Oregon and California.*
Clematis Virginiana,	*C. ligusticifolia.*
Ranunculus recurvatus,	R. occidentalis.
" fascicularis,	R. orthorhynchus.
Myosurus minimus,	M. aristatus.
Isopyrum biternatum,	I. occidentale.
Delphinium exaltatum,	D. Californicum.
" tricorne,	D. Menziesii.
Aconitum uncinatum,	A. Napellus.
Cimicifuga Americana,	*C. fœtida.*
Dicentra eximia,	*D. formosa.*
Nasturtium obtusum,	*N. polymorphum.*
" sinuatum,	N. curvisiliqua.
Dentaria heterophylla,	D. tenella.
Cardamine rhomboidea,	C. purpurea.
" rotundifolia,	C. angulata.
Viola rotundifolia,	V. sarmentosa.
" *Muhlenbergii,*	*V. adunca.*
" *Canadensis,*	*V. ocellata.*
" *pubescens,*	*V. glabella.*
Parnassia asarifolia,	*P. fimbriata.*
Hypericum mutilum,	*H. anagalloides.*
Silene Virginica,	S. pulchra.
Alsine Michauxii,	A. tenella.
Mœhringia lateriflora,	M. umbrosa.
Claytonia Caroliniana,	*C. lanceolata.*

Oxalis Acetosella,	*O. Oregana* & trilliifolia.
Geranium maculatum,	*G. erianthum & Richardsonii.*
Rhus Toxicodendron,	*R. diversiloba.*
Rhamnus alnifolius,	*R. Purshiana.*
Frangula Caroliniana,	F. Californica.
Ceanothus Americanus,	C. Oreganus.
Lupinus perennis,	L. laxiflorus, &c.
Amorpha fruticosa,	*A. Californica.*
Cercis Canadensis,	C. occidentalis.
Prunus Virginiana,	*P. demissa.*
Spiræa corymbosa,	*S. betulæfolia.*
" *salicifolia*,	*S. Menziesii.*
" *tomentosa*,	*S. Douglasii.*
Geum radiatum,	*G. calthifolium.*
Potentilla arguta,	*P. glandulosa.*
Fragaria Virginiana,	F. Chilensis.
Rubus trivialis,	R. macropetalus.
Cratægus Crus-galli,	C. rivularis?
" tomentosa,	C. sanguinea?
Pyrus coronaria,	P. rivularis.
" Americana,	P. sambucifolia.
Calycanthus glaucus & lævigatus,	*C. occidentalis.*
Myriophyllum scabratum,	M. hippuroides.
Ribes rotundifolium,	*R. divaricatum & irriguum.*
" *prostratum*,	*R. laxiflorum.*
Tillæa simplex,	T. angustifolia.
Sedum pulchellum,	S. stenopetalum.
Saxifraga Virginiensis,	S. integrifolia.
Boykinia aconitifolia,	B. occidentalis.
Heuchera Americana,	H. glabra.
" villosa,	H. micrantha.
Tiarella cordifolia,	T. trifoliata.
Chrysosplenium Americanum,	*C. glechomæfolium.*
Philadelphus inodorus,	*P. Lewisii & Gordonianus.*
Cornus florida,	*C. Nuttallii.*
" *sericea*,	*C. Drummondii.*
" stricta,	C. glabrata.
Lonicera sempervirens,	L. ciliosa, &c.
Valeriana pauciflora,	*V. capitata.*
Baccharis glomeruliflora,	B. consanguinea & pilularis.
Gnaphalium decurrens,	*G. Californicum.*
Hieracium longipilum,	H. Scouleri.
Gaultheria procumbens,	G. Myrsinites.
Azalea viscosa & calendulacea,	*A. occidentalis.*
Rhododendron maximum,	R. Californicum.
Chimaphila maculata,	C. Menziesii.
Styrax grandifolia,	S. Californica.
Collinsia verna,	C. bicolor, &c.
Chelone glabra,	C. nemorosa.
Mimulus glabratus (Jamesii, *Torr.*)	M. luteus.

Gratiola Virginiana,	*G. ebracteata.*
Castilleia coccinea,	*C. Douglasii.*
Hydrophyllum macrophyllum,	*H. capitatum.*
Nemophila microcalyx,	N. parviflora.
Ellisia Nyctelea,	E. membranacea.
Frasera Carolinensis,	F. speciosa.
Gentiana Saponaria, &c.,	G. Menziesii, Sceptrum, &c.
Fraxinus sambucifolia,	F. Oregana.
Asarum Canadense,	*A. Hookeri.*
Aristolochia Sipho,	A. Californica, *Torr.*
Platanus occidentalis,	*P. Mexicanus.*
Quercus alba,	Q. Garryana & Douglasii.
Myrica cerifera,	*M. Californica.*
Betula nigra,	*B. occidentalis.*
Alnus serrulata,	*A. rubra.*
Pinus inops,	P. distorta.
" resinosa,	P. insignis.
" Strobus,	P. Lambertiana.
Abies balsamea,	A. grandis.
Larix Americana,	*L. Mertensiana,* &c.
Thuja occidentalis,	T. gigantea.
Cupressus thyoides,	C. Nutkatensis.
Symplocarpus fœtidus,	S. Kamtschaticus.
Platanthera dilatata,	P. leucostachys.
Goodyera pubescens,	G. decipiens.
Corallorhiza multiflora,	C. Mertensiana.
" *Macræi,*	*C. striata.*
Trillium sessile,	T. petiolatum.
" *erectum,*	*T. ovatum.*
" *grandiflorum,*	*T. obovatum.*
Clintonia borealis,	C. uniflora.
Scilla Fraseri,	S. esculenta.
Erythronium Americanum,	E. grandiflorum.
Prosartes lanuginosa,	*P. Hookeri* & Smithii.
Cyperus inflexus,	*C. occidentalis.*
Vilfa vaginæflora,	V. cuspidata.
Brizopyrum spicatum,	*B. boreale?*

About 114 of our phænogamous species are therefore represented by strict analogues on the western side of the continent, —to which might be added several from the foregoing list, which are generally deemed to be distinct species;—and the number might be considerably augmented, no doubt, by further examination.

An interesting list might also be drawn up of species which are represented on the western coast by congeners not so closely related, but yet characteristic: as our

Coptis trifolia, by C. asplenifolia.
Berberis Canadensis, by B. (Mahonia) Aquifolium.
Corydalis aurea and glauca, by C. Scouleri.

Claytonia Virginica and Caroliniana, by C. alsinoides, perfoliata, flagellaris, &c.
Æsculus Pavia and flava, by Æ. Californica.
Acer Pennsylvanicum and spicatum, by A. circinatum and macrophyllum.
Œnothera, by a much larger number of species of different sections of the genus.
Mitella diphylla and nuda, by M. caulescens and pentandra.
Sanicula Marilandica and Canadensis, by a different set of species.
Our few Pentstemons, by a large number of various kinds.
Our numerous Pycnanthemums by a peculiar Californian one.
Our Trichostema dichotomum by T. lanceolatum, oblongum, &c.
Our few Phacelias by a large number of Phacelias and Eutocas.
Our Chestnut by Castanea chrysophylla, of a Western Asian type, &c.

A list of remarkable representative genera of the two sides of the continent might also be drawn up: the following are some of the more striking.

Our Sarracenia represented on the western side by the equally curious Darlingtonia, *Torr.*
Stylophorum, by Meconopsis.
Callirhoë, by Sidalcea, *Gray.*
Flœrkea, by Limnanthes.
Lobelia, by Clintonia *Dougl.* (not of *Raf.*)
Leucothöe, by Gaultheria Shallon.
Schweinitzia, by Sarcodes, *Torr.*, and an unpublished genus, Hemitomes.
Conopholis, by Boschniakia.
Monarda, by Monardella.
Tetranthera, by Oreodaphne.
Saururus, by Anemiopsis, *Nutt.*
Taxodium, by Sequoia (including Wellingtonia of Lindley).
Najas, by Lilea (Heterostylus, *Hook.*).
Zostera, by Phyllospadix.

A proper discussion of the relations existing between the vegetation of the eastern and western sides of the continent would demand a notice of the remarkable *absence* west of the Rocky Mountains of a great variety of genera, tribes, and even orders, which are eminently characteristic of the flora of the Eastern States. For example, Oregon and California have no *Magnoliaceæ*, *Anonaceæ*, *Menispermaceæ*, nor *Cabombaceæ*, no *Nymphæa*, although a Nuphar is plentiful, no *Tilia* or Bass-wood, no *Camelliaceæ*, no indigenous Grape-vines, except one in California, only one *Polygala*, no Locust or other Leguminous trees, no Passion-flowers, no *Hydrangea*, no *Hamamelaceæ*, few *Rubiaceæ*, no *Vernoniaceæ*, and very few *Eupatoriaceæ*, very few *Asters* and *Solidagoes* (but the numerous *Compositæ* tend strongly to *Heleniæ*, and are mostly of genera which are neither Eastern

North American nor European in type), no *Lobelia*, no true Huckleberries (*Gaylussacia*) nor *Vaccinia* of the Blueberry type, (the section *Cyanococcus*), no *Clethra*, and few *Andromedeæ*, no *Aquifoliaceæ*, *Ebenaceæ*, nor *Sapotaceæ*; no true *Bignoniaceæ*, no *Acanthaceæ*, nor Gerardias, no *Sabbatia*, no *Dirca* nor *Podostemon*, solitary representatives here of their respective orders; no *Empetraceæ*, no Elms (although there is a *Celtis*), no Mulberry, no Walnuts, Hickories, or other *Juglandaceæ*, nor a Beech, Hornbeam nor Ironwood, no true *Araceæ*, *Hydrocharidaceæ*, *Hæmodoraceæ*, *Burmanniaceæ*, *Dioscoreaceæ*, *Pontederiaceæ*, *Commelynaceæ*, *Xyridaceæ*, or *Eriocaulonaceæ*, few *Orchidaceæ*, and still fewer *Cyperaceæ*, none of the latter either *Rhynchosporeæ* or *Scleriæ*, and Paniceous and Andropogineous Grasses are altogether absent.

How these failures are made up by a large increase of peculiar generic and specific forms in a few families, I will not stop to illustrate. But it is worth noticing that, while our eastern flora possess so many orders which are not represented in the western, no order represented in Oregon or California is wanting in the flora of our Northern States, unless *Hydroleaceæ* and *Garryaceæ* be counted as independent orders; and both of these occur in the Atlantic states south of our geographical limits.

The Distribution through degrees of latitude of the Phænogamous Species generally of the Flora of the Northern United States.

Having devoted the greater part of our last article to the investigation of this subject as respects about 15 per cent of our species,—namely those common to this country and to Europe,—I shall not be expected to elaborate the range of our whole 2091 Phænogamous plants in the same detailed manner.

I have investigated, in this regard, the shrubs and trees separately from the herbaceous plants; the former being moderate in number, and those which extend into British America affording us the advantage of having had their northern limits laid down by Sir John Richardson, in the invaluable appendix to his Arctic Searching Expedition. Of our Phænogamous species about

1745, or 83·5 per cent, are herbaceous plants.
218, or 10·3 per cent, are shrubs or woody vines.
130, or 6·2 per cent, are trees.

Northward and Southward Range in this country of our Shrubs and Trees.

The average range in America of our 348 woody plants is through about 13½ degrees of latitude.

The 15 following species are those which appear to have the greatest range north and south, namely, through from 30 to 40 degrees of latitude.

	Northern limit.	Southern limit.	Range.
Prunus serotina, -	61°	29°	32°
" Virginiana, -	66	31	35
Rosa blanda,* -	69	39	30
Amelanchier Canadensis,*	66	30	36
Cornus stolonifera, -	69	38	31
Viburnum acerifolium,*	62	31	31
Arctostaphylos Uva-ursi,*	70	36	34
Cassandra calyculata,	67	34	33
Alnus viridis,* - -	68	35	33
Salix discolor, - -	67	36	31
" lucida,* - -	67	37	30
" longifolia,* -	68	35	33
Populus tremuloides, -	69	37	32
Abies nigra, - -	68	34	34
Juniperus Virginiana, -	67	26	41

All of these species, with four or five exceptions, extend into the Southern United States only along the Alleghany Mountains; consequently their climatic range is not so great as would at first appear. Those which have an extraordinary climatic range, being natives both of the Arctic and Subarctic regions and of the low country bordering the Gulf of Mexico are the following.

Viburnum acerifolium. In the Southern States this is not met with far from the Alleghany Mountains, and the few specimens I have seen from Middle Florida are of doubtful character.

Amelanchier Canadensis. The Shad-flower or Service-berry prefers the mountains or their vicinity, but is not unknown in some parts of the low country as far south as Florida.

Prunus serotina. The Wild Black Cherry ranges from near Great Slave Lake, at the north, well into Florida and Texas, and into the adjacent parts of Mexico. Although it varies from a moderate-sized shrub to a large tree, I have no idea that more than one species is covered by this name.

Prunus Virginiana. The Choke Cherry extends from the borders of the Arctic Circle to Louisiana, &c.; but in the Southern States it is chiefly restricted to elevated districts.

Juniperus Virginiana. The Red Cedar, with its immense range, in the United States inhabits the warmer rather than the colder districts of the country, and extends on the Gulf of Mexico quite to the mouth of the Rio Grande. As a tree it does not occur north of about lat. 54°, but the low and spreading or prostrate form, which, with Sir William Hooker I have not been able to distinguish specifically from J. Virginiana, advances a short distance within the Arctic Circle, where, according to Sir John Richardson, it bears fruit at an elevation of 1000 feet, Sir William Hooker unites not only this northern form, but the Red Cedar generally with *Juniperus Sabina* of Europe, which in this case ranges over nearly the whole extent of the northern hemisphere. I am not yet prepared to adopt this view.

If the high northern prostrate Savin is rightly referred to *Juniperus Virginiana*, this species extends from within the Arctic Circle to the Gulf of Mexico. It is the only woody plant which does so, except perhaps *Amelanchier*, which has been traced almost to the Arctic Circle, and possibly *Prunus Virginiana*.

Alnus viridis occurs southward only on the highest Alleghanies.

We naturally enquire whether these fifteen species range widely east and west. Seven of them, those to which an asterisk is annexed, extend from the Atlantic to the Pacific, or very nearly, south of lat. 46°; and of these only two (*Arctostaphylos Uva-Ursi* and *Alnus viridis*) are indigenous to the Old World. *Cornus stolonifera*, *Prunus serotina* and *P. Virginiana*, and probably *Salix discolor*, all peculiarly American, reach or cross the Rocky Mountains. *Cassandra* (of which I have some doubt about its reputed southern range to Georgia) is wholly eastern, and is also European. *Populus tremuloides* and *Abies nigra* are both exclusively Eastern North American in habitation.

The following 68 species of woody plants, range with us through between 20 and 29 degrees of latitude.

— * Tilia Americana.
† Rhus glabra.
— † " aromatica.
— * Vitis cordifolia.
— † Ampelopsis quinquefolia.
— † Acer rubrum.
— † Negundo aceroides.
— * Amorpha fruticosa.
— * Prunus Americana.
— * Spiræa opulifolia.
† " salicifolia.
† Rubus occidentalis.
— † " villosus.
‡ Potentilla fruticosa.
— * Pyrus arbutifolia.
† Ribes Cynosbati.
† " hirtellum.
‡ " lacustre.
‡ " rubrum.
‡ Lonicera cærulea.
† Sambucus pubens.
— † " Canadensis.
‡ Viburnum Opulus.
† Gaylussacia resinosa.
‡ Vaccinium Vitis Idœa.
‡ " Oxycoccus.
‡ Vaccinum uliginosum.
‡ " Canadense.
‡ Arctostaphylos alpina.
— † Epigæa repens.
‡ ? Cassiope hypnoides.
‡ Andromeda polifolia.
— † " ligustrina.
‡ Phyllodoce taxifolia.
‡ Kalmia glauca.
† Menziesia ferruginea.
‡ Rhododendron Lapponicum.
‡ Loiseleuria procumbens.
— † Fraxinus Americana.
‡ Shepherdia Canadensis.
‡ Empetrum nigrum.
— * Ulmus fulva.
— † " Americana.
— * Quercus obtusiloba.
— † " alba.
— † " rubra.
— * Fagus ferruginea.
— † Corylus Americana.
— † Ostrya Virginica.
‡ Myrica Gale.
† Comptonia asplenifolia.
‡ Betula pumila.

‡ Betula nana.
‡ " papyracea.
‡ Alnus incana.
‡ Salix cordata.
‡ " rostrata.
‡ " phylicifolia.
‡ " pedicillaris.
‡ " Uva-Ursi.
‡ Salix repens.
‡ " herbacea.
‡ Pinus Banksiana.
† Abies balsamea.
‡ " alba.
‡ Larix Americana.
† Cupressus thyoides.
‡ Juniperus communis.

The mark — prefixed to the name indicates that the species extends southward to the borders of the Gulf of Mexico. The asterisk * denotes a range northward to the Great Lakes; †, to the basin of the Saskatchawan; ‡ to the Arctic Circle, or at least to lat. 67°.

It appears then that 34 species, or one half of this list, are of boreal or alpine character, ranging northward to or within the Arctic Circle. Fifteen of these are exclusively alpine or subalpine plants, and occur only on our higher mountains as far south as lat. 44°. Of the rest, those of greatest climatic range are, *Alnus incana*, ranging from about lat. 68° to 39°; *Salix cordata*, with an equally wide range and probably reaching further south; *Larix Americana*, with about the same southern limit, but in an elevated region only; *Juniperus communis*, not found south of lat. 40°; *Myrica Gale*, and *Ribes Cynosbati*, *Potentilla fruticosa*, *Kalmia glauca*, *Betula pumila*, and perhaps *Ribes lacustre*, each have a range of 28 or 29 degrees, but none of them are found south of lat. 40°.

Twenty-two species of the foregoing list extend northward into the Saskatchawan basin, and all but three of them (which cross the 60th parallel and occur in the basin of the Great Slave Lake) find their northern limit there.

On the other hand, 24 species extend southward to the borders of the Gulf of Mexico. Fourteen of these have their boreal limit in the Saskatchawan district, and nine about the Great Lakes.

The following species, 57 in number, range through from 15 to 19 degrees of latitude:

† Hudsonia tomentosa.
* Rhus typhina.
— * " venenata.
— * " Toxicodendron.
— * Ptelea trifoliata.
— * Vitis Labrusca.
† Rhamnus alnifolius.
— * Ceanothus Americanus.
† Acer Pennsylvanicum.
† " spicatum.
* Acer saccharinum.
* " dasycarpum.
* Amorpha canescens.
† Prunus Pennsylvanica.
† Spiræa tomentosa.
† Rubus odoratus.

	†	" strigosus.	
—	*	Rosa setigera.	
—	*	" lucida.	
—	*	Cratægus coccinea.	
—	*	Cratægus tomentosa.	
	†	Ribes prostratum.	
	†	" floridum.	
—	*	Hamamelis Virginica.	
	*	Cornus sericea.	
	†	Symphoricarpus occidentalis.	
	†	" racemosus.	
	†	Lonicera parviflora.	
	†	" ciliata.	
	†	Diervilla trifida.	
—	*	Viburnum nudum.	
	†	" Lentago.	
	†	" pubescens.	
	*	" lantanoides.	
	†	Vaccinium macrocarpon.	
—	*	" corymbosum.	
	*	Gaultheria procumbens.	
—	*	Kalmia latifolia.	
	*	" angustifolia.	
—	*	Azalea viscosa.	
—	*	" nudiflora.	
	†	Nemopanthes Canadensis.	
	*	Fraxinus pubescens.	
—	*	" viridis.	
—	*	Benzoin odoriferum.	
—	*	Platanus occidentalis.	
	†	Corylus rostrata.	
—	*	Carpinus Americana.	
—	*	Myrica cerifera.	
	*	Salix eriocephala.	
	†	" petiolaris.	
—	*	" angustata.	
—	*	Populus angulata.	
	†	" balsamifera.	
	†	Pinus resinosa.	
	†	Thuja occidentalis.	
—	*	Smilax rotundifolia.	

The marks prefixed to the names have the same signification as in the preceding list.

Not one of these species are alpine, or even subalpine, nor found within several degrees of the Arctic Circle. Only two of them (viz., *Symphoricarpus occidentalis* and *S. racemosus*) reach the 60th parallel, or the great northern basin. Twenty-four of them have their boreal limit in the Saskatchawan or Hudson's Bay region; and all of them extend as far north at least as to the Great Lakes, although a few (such as *Ptelea trifoliata* and *Populus angulata*) barely touch their most southern borders, viz., the south shore of lakes Erie and Michigan.

Twenty-three species range southward to the borders of the Gulf of Mexico or very nearly, while their boreal limit is on or near the Great Lakes, between 41° and 49°.

Without carrying this analysis any farther, let us turn to the shrubs and trees of narrowest northern and southern range. Those whose range is not known to exceed six degrees of latitude are 33 in number, viz:

Magnolia macrophylla.
" Umbrella.
Berberis Canadensis.
Hypericum Kalmianum.
Æsculus glabra.
Robinia Pseudacacia.
" viscosa.
Cladrastis tinctoria.
Spiræa corymbosa.
Cratægus cordata.
Calycanthus glaucus.
Fothergilla alnifolia.
Lonicera hirsuta.
" oblongifolia.
Baccharis glomeruliflora.
Gaylussacia brachycera.

Vaccinium erythrocarpon.
Leucothoë Catesbæi.
" recurva.
Andromeda floribunda.
Clethra acuminata.
Azalea arborescens.
Rhododendron Catawbiense.
Styrax Americana.
Ulmus racemosa.
Juglans nigra.
Carya microcarpa.
" sulcata.
Quercus palustris.
Pinus pungens.
Abies Fraseri.
Smilax Walteri.
" hispida.

Fifteen, or 45½ per cent of these are trees; and out of 14 whose range is under four degrees of latitude, six are trees.

On the other hand, out of 140 species of wide or considerably more than average range, enumerated in the preceding lists, 42 (i. e. 30 per cent) may be counted as trees. Now, as almost 60 per cent of our woody plants attain under favoring circumstances the stature of trees, the general impression, that trees are more limited in range than shrubs, is not confirmed by the list last given, in which the percentage of trees is diminished instead of enlarged; but seems decidedly to be so by the list of wide-ranging species, even after the exclusion of the alpine plants, which of necessity are not trees. That is, local species are about as likely to be shrubs as trees, but shrubs are in general more widely distributed than trees.

A very few of our shrubs and trees, if rightly determined, extend southward much beyond the southern boundaries of the United States. Those which do so, principally, *Ascyrum stans* and perhaps *Zanthoxylum Carolinianum*, in the West Indies; and *Negundo aceroides*, *Sambucus Canadensis*, *Cephalanthus occidentalis*, *Vaccinium stamineum*, *Salix angustata*, and *Taxodium distichum*, in Mexico.

Northward and Southward range in this country of Herbaceous Plants.

Upon this subject my statements must be brief and general. Of the 1745 phænogamous herbaceous plants of the Flora of the Northern United States, diminished to about 1690 by the exclusion of the alpine and subalpine species, here left out of view—

843 species, or 50 per cent, range southward to the borders of the Gulf of Mexico.

538, or not quite 32 per cent, extend northward into the Saskatchawan basin or to Labrador.

107 of these reach or cross the Arctic circle.

24 species, or less than 1½ per cent, range from the Gulf of Mexico to the Arctic circle.

180, or 10½ per cent, range from the Gulf of Mexico to the Saskatchawan or Labrador.

248 species, or over 14½ per cent, range from the Gulf of Mexico to the Great Lakes or the St. Lawrence.

The twenty-four herbaceous plants of widest climatic range are

Ranunculus aquatilis.
" Cymbalaria.
" Purshii.
" sceleratus (a doubtful native southward).
Sarracenia purpurea.
Nasturtium palustre.
Cardamine hirsuta.
Barbarea vulgaris (not indigenous at the south?).
Sisymbrium canescens.
Viola cucullata.
Drosera rotundifolia.
Spergularia rubra.
Lupinus perennis (if the plant growing on the Arctic sea-coast is correctly referred to this species).
Galium trifidum.
" triflorum.
Erigeron Philadelphicum.
Achillea Millefolium (probably introduced southward).
Senecio aureus.
Taraxacum Dens-leonis.
Dodecatheon Meadia.
Chenopodina maritima?
Potamogeton pectinatus.
Luzula campestris.
Carex Novæ-Angliæ.

All except three or four of these species range westward to the Pacific; but one, *Sarracenia purpurea*, is remarkably restricted to the vicinity of the Atlantic. Only the seven printed in italics are indigenous to North America exclusively.

The Range of our Species compared with the size of the Genera they belong to.

The data before us may be used to test Mr. Darwin's surmise, that the species of large genera on the whole occupy a greater geographical area than those of small genera. Certainly almost half of the herbs of the last preceding list belong to very large genera; and all but four of them to genera of more than average size, that is, of more than ten or twelve species. I find, also, that 126 out of the 180 herbaceous species which range from the Gulf of Mexico to the Saskatchawan or Labrador, viz. 70 per cent, belong to genera containing above the average amount of species each, and about 112 of them belong to genera which are represented in the Flora of the Northern United States by above the average of indigenous species to genus.

And our woody plants of wide range tend more strongly to confirm this view, as the following table shows.

Woody plants ranging through	Whole No. of species.	Belonging to Genera,		
		Of great size.	Of more than average size, i. e. of over 10 species.	Of a single species or nearly so.
30°–40° of latitude.	15	3	13	1
20° " "	68	20	48	6
15° " "	57	7	44	1
	140	30	105	8

That is, in the first list, or in the species of widest range, 86½ per cent; in the second, 70½ per cent; in the third, 76 per cent, or in all three together 75 per cent of the species belong to genera of above the average size.

The converse does not tell in the same way, so far as our list of 33 species of narrowest range shows; for at least 21 of them belong to genera of above the average size, and only two are monotypic. But here the particulars are too few to draw any useful induction from.

Species of the Northern United States which have some other and widely sundered habitation.

The plants which I here have in view belong to DeCandolle's category of *Disjoined Species* (Espèces Disjointes),* or those of which the individuals exist in two or more separated countries, and which cannot reasonably be regarded as having been conveyed from one to the other by any existing means of transport, whether on account of their mode of life, the character of their seeds, the extreme distance of their habitations, or any other reason. I restrict myself, however, to only one, and that a small, portion of the numerous species which DeCandolle treats of under this head. For in this view almost all the undoubtedly indigenous phænoganous plants common to this country and to the Old World are disjoined species. I exclude both those species which are rather widely distributed in Northern Europe or Asia as well as in this country, and those which are dispersed over a very considerable portion of the terrestrial surface of the globe,† and consider only those of remarkably isolated as well as distant habitats.

The following are the principal cases of the kind with which we have to do.

Anemone multifida. North America, from lat. 42° northward. South America from Chili, and perhaps Peru, southward.

Trautvetteria palmata. Illinois to Tennessee. Oregon on the Pacific: no intermediate station known.

Myosurus minimus. Florida and Georgia to Illinois, and west to Oregon and California. Europe, north to Finland.—It is remarkable that along with the common Mousetail in Oregon grows the only other species of the genus, *M. aristatus, Benth.;*

* *Géographie Botanique*, 2. p. 993.

† DeCandolle (*Géogr. Bot.*, 1. p. 564) gives a catalogue of 117 Phænogamous species which are now dispersed (whether by naturalization or otherwise) over at least one-third of the terrestrial surface of the globe,—a number which he supposes might be raised to 200. Some botanists, uniting nominal species, would add considerably to the number. Our *Flora of the Northern United States* comprises 103 of these, and perhaps should have comprised two or three more. Of this number 58 are reckoned as indigenous plants, and 45 as introduced species. A few species are probably to be transferred from the indigenous to the naturalized list, viz., *Galium Aparine, Gnaphalium uliginosum, Juncus bufonius*, and perhaps *Poa annua.*

which elsewhere occurs only in Chili, where it is the *M. apetalus* of Gay.

Brasenia peltata. Canada to Florida and Eastern Texas. Eastern Himalayas, Japan (*fide* Planchon), Eastern Australia. The only known species of the genus. The other genus of this group, *Cabomba*, was once thought to furnish another case of great disjunction; the original species inhabiting Cayenne and Brazil being long supposed to be identical with the species of the Southern United States. The latter I distinguished twenty years ago, chiefly by the form of the floating leaves, under the name of *C. Caroliniana;* but I should not be surprised if it were eventually reunited to *C. aquatica.*

Subularia aquatica. As already stated in a former article (vol. 23, p. 65), the only known stations of this plant in the New World are at most two, one in Maine, the other in New Hampshire. But it is a plant very likely to be overlooked. Northern Europe to lat. 70°, and Siberia.

Silene Antirrhina. United States, south to the borders of Mexico, and perhaps farther. South Brazil and Northern Patagonia.

Cerastium arvense. Northern parts of N. America and in the Old World. South Brazil and Chili to the Falkland Islands, according to Dr. Hooker.

Sagina procumbens. Northeastern States, rare. Falkland Islands. Perhaps not indigenous in the New World. Europe.

? *Elatine Americana.* New Hampshire to Kentucky. New Zealand! according to Dr. Hooker. But a further comparison is desirable.

? *Lathyrus maritimus.* Coasts of N. America north of lat. 40°, and in corresponding parts of the Old World. Southern border of Chili, lat. 47° S. Needs fuller confirmation.

Potentilla anserina. Pennsylvania to California and northward, and northern part of the Old World. Chili. New Zealand.

Potentilla frigida. Alpine region of the White Mountains of New Hampshire. Greenland. Swiss Alps.

? *Potentilla tridentata.* Alleghany Mountains to Arctic America, lat. 64°; generally subalpine, but found on the Coast of Massachusetts (Cape Cod, H. J. Clark,) and Maine; Labrador and Greenland. Clova Mountains, Scotland; found many years since by G. Don but by no one else. I had omitted to mention this as a European species, having the impression that it was supposed to have been wrongly introduced into the Flora of Great Britain. Hooker and Arnott, however, still retain it, although marking it as extinct. If it was really found indigenous in Scotland, then it is (as Prof. Tuckerman has aptly remarked to me) an exact counterpart to *Carex fulva*, which was first detected in this country, and once gathered in Massachusetts, but never found again in America, although it has proved to be not uncommon in

Western Europe. These indications of the extinction of a species on one side of the Atlantic, while it flourishes on the other, are very significant.

Circæa Lutetiana. This is not recorded from any station north of lat. 46°, nor west of the Mississippi. In Europe it ranges north to Scotland and Finland and east to Altai. Hence De Candolle includes it in his list of remarkably disjoined species.

Hippuris vulgaris. Rare in this country, but extending from far north to lat. 36° along the Rocky Mountains, and reappearing in Patagonia.

Sium lineare. Florida to the Saskatchawan and northern Oregon. Siberia.

Cryptotænia Canadensis. Eastern United States and Canada. Japan, *fide* Zuccarini.

Heracleum lanatum. Northern United States to Newfoundland; Oregon and Sitcha. Japan.

Hydrocotyle Americana. Eastern United States. Brazil. New Zealand, (*fide* Dr. Hooker.)

Crantzia lineata. Massachusetts to Texas. Buenos Ayres to the Falkland Islands. New Zealand.

Osmorrhiza longistylis. Northern United States and Canada to Oregon. Japan! (*O. Japonica*, Zucc.)

Aralia quinquefolia (*Panax quinquefolium*, Linn.). Canada to Georgia along the mountains. China? and Himalayas, (*P. Pseudo-Ginseng*, Wall.)

Viburnum lantanoides. Northern States, not crossing the Alleghanies, and Canada. Japan! (*V. plicatum*, Thunberg.)

Matricaria discoidea. St. Louis, Missouri. Probably a recent immigrant from Oregon, although thoroughly established. California to Unalaschka and adjacent parts of Asia. Sweden! Doubtless of recent introduction, but how introduced is unknown.

Monotropa uniflora. Canada to Louisiana; Oregon. Falls of Tequendama, New Granada, *Prof. Holton!* Sikkim and Khasian Himmalayas, *Dr. Hooker!* This isolated occurrence of a plant so peculiar in appearance and mode of life, in these districts so widely separated from each other, furnishes far the most remarkable case of anomalous distribution I know. The species is unknown north of Canada, and must be rare west of the Mississippi, as Nuttall alone mentions it from Oregon. But I should not be surprised to hear of it from Japan on the one hand, and the Mexican Andes on the other.

Plantago maritima, var., *juncoides*, &c. Northern hemisphere; on the Atlantic coast of North America south to lat. 40°; on the Pacific coast to lat. 36°. Straits of Magellan.

Primula farinosa. Northern hemisphere; in the United States south to lat. 42°, and in the Rocky Mountains to lat. 39°. Straits of Magellan and Falkland Islands!

Centunculus minimus. Florida to Illinois and Oregon, Southern Brazil! Europe, north to Norway. Perhaps introduced into Brazil?

Phryma Leptostachya. Canada to Florida; not found west of the Rocky Mountains. Nepal!

Veronica Anagallis. Around the northern hemisphere, in the temperate zone. New Zealand, *fide Dr. Hooker.*

Veronica serpyllifolia. Around the northern hemisphere. Quito and Falkland Islands, &c. Cape of Good Hope. Perhaps introduced in the southern hemisphere.

Dichondra repens. Virginia to Chili. New Zealand. Tasmania to Eastern Africa. Cape of Good Hope.

? *Salicornia mucronata.* Coast of New England; also on the coast of Spain, if the plant of Lagasca under this name is the same as ours. The two have never been compared; and the main object in the present mention of them is to ask that this may be done.

? *Castanea vesca.* Eastern United States, north to lat. 44°. Southern and Eastern Europe. (Vide vol. 23, p. 65.)

Betula alba. Northeastern United States, from lat. 40° to 46°. Northern Europe to the Arctic regions, and Siberia.

Convallaria majalis. Mountains of Virginia and Carolina. Europe and Northern and Eastern Asia. Japan.

? *Polygonatum latifolium.* Pennsylvania. Central and Southern Europe.

Smilacina stellata. Northern States to California, Oregon and Labrador. Norway.

Smilacina trifolia. Northern States, and from Labrador to Bear Lake, and the Rocky Mountains. Siberia.

Trillium erectum var. *album.* Northern States and Canada. Japan!

Vallisneria spiralis. United States east of the Mississippi, and Canada to lat. 46°. France to Italy; near St. Petersburgh? also on the Wolga. India?

Anacharis Canadensis. Eastern part of Canada and the United States. New Granada to Chili. Probably in intermediate stations.

Zannichellia palustris. Northern hemisphere, only in temperate regions; neither arctic nor tropical. New Zealand.

? *Spiranthes cernua.* United States, Canada, and Oregon. Western coast of Ireland.

Xerophyllum asphodelioides. New Jersey to Carolina; but nowhere west of the Alleghanies, except in Oregon and California.

Juncus stygius. Northern New York at one station. Newfoundland. Scandinavia; Bavaria and Switzerland.

? *Juncus maritimus.* Coast of the Atlantic United States south of lat. 40°. Europe, &c.

Eriocaulon septangulare. Eastern United States, north of lat. 40°, to the Saskatchawan and Newfoundland. Western Coast of Ireland, Isle of Skye, and the Hebrides.

Hemicarpha subsquarrosa. United States from Maine? to Texas. Brazil.

Rhynchospora fusca. Northeastern United States, lat. from 40° to 44½°. Europe south of Sweden.

Carex flacca. New Jersey, lat. 40°. Europe from Finland southward.

Carex lævigata. Massachusetts? England to Portugal.

Carex fulva. Massachusetts; found only once. Newfoundland; where it was first detected, but has not been found again. W. Europe from Finland southward.

Carex canescens, Linn., (*C. curta*, Good.) Colder parts of the Northern hemisphere, south to lat. 40° in this country. Antarctic America.

Carex stellulata. Same general northern range as the last. New Zealand, *fide* Dr. Boott.

Carex teretiuscula. Same general range as the last. New Zealand, *fide* Dr. Boott.

Phleum alpinum. Alpine and Arctic regions in the northern hemisphere. Antarctic America, *fide* Hooker.

Agrostis canina. Only subalpine in the United States. Falkland Islands, *fide* Hooker.

?*Spartina juncea.* Atlantic coast of the United States. French coast of the Mediterranean, at one station only, near Fréjus. A chance introduction?

Spartina stricta (*S. glabra* and *S. alterniflora*). Atlantic coast of the United States to Guadeloupe and Cayenne. Coast of England to the Adriatic; at few stations. A case of accidental or oceanic transport?

Kœleria cristata. Temperate and colder regions of the northern hemisphere. New Zealand and Tasmania, *fide* Hooker.

Glyceria fluitans. Same general range as the last. Australia.

Poa nemoralis. Northern and colder parts of North America; more common in Europe. Antarctic America, *fide* Hooker.

Poa pratensis. Same general distribution as the last. Antarctic America, *fide* Hooker.

Festuca ovina. Same distribution as the preceding. New Zealand, *fide* Hooker.

Triticum repens. Same distribution generally as the preceding. Antarctic America, *fide* Hooker.

Hordeum jubatum. Atlantic and Pacific coasts of North America, chiefly northward on this side, and south to California on the other; also along the Great Lakes. Chili? Straits of Magellan, *fide* Hooker.

Aira flexuosa. Northern hemisphere, throughout the cooler parts. Patagonia and Falkland Islands.

Aira cæspitosa. Colder parts of the northern hemisphere. Antarctic America and New Zealand, *fide* Hooker.

Trisetum subspicatum. Alpine and arctic exclusively in Europe, Asia and N. America (except the var. *molle*, which is rarely ever subalpine in the Northern States); advancing south along the Rocky Mountains to about lat. 40°. Andes of Mexico, Colombia, and Peru, *fide* Hooker. Antarctic America and Campbell Islands: also Tasmania, *fide* Hooker.

Hierochloa borealis. Around the colder parts of the northern hemisphere. New Zealand, and Tasmania, *fide* Hooker.

To this list of 69 phænogamous species of our flora inhabiting very widely sundered stations, the following Ferns should be appended, namely:

Scolopendrium officinarum. Banks of a deep ravine in Madison County, New York, where it abounds; the only American habitat known. Europe and Northern Asia.

? *Camptosorus rhizophyllus.* Atlantic United States, chiefly along the Alleghanies, and north to the Saskatchawan. Siberia and Kamtschatka?

Adiantum pedatum. Eastern United States and Canada to Oregon and Unalaschka. Kamtschatka, Japan, Nepal.

Aspidium Lonchitis. Lake Superior, Rocky Mountains. Unalaschka, Northern Europe and Asia from Lapland to Altai.

Schizæa pusilla. Pine barrens of New Jersey, lat. 39½°–40°; very local, but abundant. Newfoundland; lat. 49°; and not elsewhere.

I do not include in this enumeration *Saururus cernuus* and *Stachys aspera*, adduced by DeCandolle as species extraordinarily disjoined and isolated. The latter I have considered as merely a variety of the polymorphous and widely diffused *S. palustris*. The second DeCandolle mentions on the authority of Hooker and Arnott, who were unable to distinguish Chinese specimens from our *Saururus cernuus*. But Japanese specimens of what I take to be *S. Loureiri*, Decaisne, seem to be marked by good specific characters. An analogous case, still needing examination is that of *Penthorum Chinense*, which the elder DeCandolle, however, distinguishes from our *P. sedoides* by its seeds.

These species of widely sundered habitation arrange themselves, for the most part, under three heads, viz:

1. Those which re-appear in high southern or antarctic latitudes. These, the most remarkable of all, are about 34 in number, or nearly half of our list. And to this number might be added several other species, common to our northern and to high southern regions, but not occurring in our Flora; such as *Draba*

incana, *Montia fontana*, *Saxifraga exarata*, *Erigeron alpinum*, *Statice Armeria*, *Carex festiva*, and *Alopecurus alpinus*, enumerated in Hooker's Flora Antarctica, as both Arctic and Antarctic American as well as European species.

2. Those which re-appear in Japan, the Himalaya, or some part of Northern Asia, but are not European; of which the following are the principal: viz, *Brasenia peltata*, *Sium lineare*, *Cryptotænia Canadensis*, *Heracleum lanatum*, *Osmorhiza longistylis*, *Aralia quinquefolia*, *Viburnum lantanoides*, *Monotropa uniflora*, *Phryma leptostachya*, *Smilacina trifolia*, *Trillium erectum*, var., *Camptosorus rhizophyllus*, and *Adiantum pedatum*. A goodly number of species common to Northwestern America and Japan, and of others common to the Himalayas, Europe, and North America, although as yet known from but few stations throughout large parts of this belt (such as *Spiræa Aruncus*, *Pyrola rotundifolia*, &c.,) and whose dispersion is scarcely more explicable than that of the foregoing by any existing agencies, serve nearly to bridge over the wide gap which, at first view, appears so markedly to separate these extraordinarily sundered plants from the generality of species.*

3. Species of Western Europe and (chiefly) Eastern North America, not reaching here to high latitudes, and mostly of limited range on one or the other side of the Atlantic. Of this sort are *Myosurus minimus* (in this country remarkably southern, but also far western in range), *Subularia aquatica*, *Circæa Lutetiana*, *Betula alba*, var., *Convallaria majalis*, *Juncus Stygius*, *Carex flacca*, *lævigata*, and *fulva*, *Scolopendrium officinarum*, and *Aspidium Lonchitis*, all much more local in this country than in Europe; and on the other hand, *Potentilla tridentata*, *Smilacina stellata*, *Vallisneria spiralis*, *Spiranthes cernua*, *Spartina stricta*, and *Eriocaulon septangulare*, all common and for the most part rather widely distributed plants in this country, but very local in Europe. All but four species on this list belong exclusively to the Atlantic border of North America. Cases of this kind are naturally regarded by some as indications of a former terrestrial connection between North America and Europe.

Only three or four of these species of widely sundered stations are maritime, and of these only *Spartina* and the *Salicornia* (if the latter be the same on both sides of the Atlantic, which there is no evidence of) could owe their present dispersion to oceanic currents. The light fruits of *Circæa* are provided with minute hooks; those of *Heracleum* and *Betula* are winged; the spike of

* Out of 49 species belonging to these first and second heads, as many as 10 belong to monotypic genera, and 21 to genera of less than ten good species;—six of the species belong to the vast genus Carex;—on the whole rather militating against the idea that the geographical extension of species bears some proportion to the size of the genus they belong to.

Hordeum jubatum breaks up into short joints, and the persistent glumes and the paleæ enclosing the seed are long-awned. But no others of the 69 phænogamous species above enumerated enjoy peculiar facilities for, or are endowed with any appliances favorable to adventitious transport.

Such cases, accordingly are much relied upon by its advocates in proof of the doctrine of the double or multiple origin of species. Even DeCandolle, who formerly maintained that doctrine, but whose matured opinion favors the idea that species of plants generally originated each in a single birth-place, is still inclined to view such cases as exceptions to the general rule. A fuller investigation will probably do away with this intermediate hypothesis. If the dispersion of other plants generally could be accounted for by existing agencies acting under the present state of things, and if there were really any marked line of difference to be drawn between these and other widely dispersed but less isolated species, the supposition of a double birth-place for the exceptional species would be the most natural; although one would then be inclined to regard them as mostly cases of closely related species whose points of difference are still unascertained or undervalued. For we no more know how nearly alike two species may appear and yet be specifically distinct, than we know how widely they may differ and yet own a common origin. The botanist's best conclusions regarding the limitation of species are seldom more than judgments on imperfect data, constantly liable to be questioned and revised.

But both these most striking cases, and the transitional ones between them and those of ordinary distribution, are becoming too numerous to bear this exceptional mode of explanation. DeCandolle lays much stress upon the isolated occurrence of a single peculiarly United States species, *Phryma leptostachya*, in Nepal. Now the foregoing catalogue includes three or four additional cases of the same kind, which Drs. Hooker and Thomson's Himalayan collections may probably double; and the considerable number of North American species which meet Himalayan ones in Japan already indicates the line of connection between these two distant floras. We should therefore look in one and the same direction for the explanation of these extraordinary no less than of the more ordinary cases of distribution, and, adopting the conclusion to which DeCandolle himself arrives, and maintains on various and convincing grounds,—viz., that plants must have been created at different epochs, and that the greater part of the existing species are older than the present configuration of our continents,—should refer such anomalous distribution to very ancient dispersion; and all the more confidently as the known examples of the kind increase in number.

As the discussion of this most difficult problem proceeds, the two antagonistic positions only seem likely to be tenable;—the one attributing much to changes of station, etc., occurring during a long lapse of time, and the other looking upon the whole actual area of each species as its original home. The supporters of the first view regard each species as having spread from a single and local birth-place, or even, as the more thorough-going (like Dr. Hooker) maintain, from a single individual or pair. The opposing view finds its hardiest and most consistent advocate in Agassiz, who contends, if I rightly apprehend him, that each species probably originated in as many individuals, and covering from the first as large an area as it subsequently possessed.

Of the first-named theory, the only question is whether it will sufficiently explain all the facts of distribution; the second supersedes the necessity of such explanation, by assuming the actual distribution to be essentially the original state. The first theory is based upon the natural idea of species as consisting of kindred individuals descended from a common stock, which, whether demonstrable or not as a fact, gives us a clear and distinct conception of *species*, and the only one we possess. The second theory, being incompatible with this conception, leaves species no objective basis in nature, and seems to make even the ground of their limitation a matter of individual opinion.

The Distribution of our Phænogamous Species, and of the Individuals which represent them, within the limits of our Flora.

The distribution of the materials of our flora over the surface included within its limits, is a subject which I have not room nor time left for discussing with anything of the fullness it deserves. Properly to discuss this and kindred topics would require a great amount of detailed investigation, and would expand these articles into a treatise.

Viewed as to its amount or prominence, the importance of each species as a constituent of our flora depends upon the extent of country it ranges over, and the relative abundance of its individuals. To get some general idea of both points, I have gone over the pages of the *Flora of the Northern United States*, and indicated by peculiar marks, 1, those species which are very local, either absolutely so, or because they barely enter within our borders, however widely they may range beyond them on any side; 2, those of narrow or restricted range within our limits, not extending over more than a tenth or an eighth part of our territory; and 3, wide-spread species, which have been found over nearly the whole length and breadth of our territory. Then, by a different set of marks I have indicated, 1, those species which are very scarce in individuals in their proper habitat; 2, those which are not abundant in individuals; and 3,

those which ordinarily are very abundant in individuals wherever they occur. The latter includes our *social plants*, as well as a larger number which could not properly be so called. I should have distinguished the really social plants from the others if I knew how to draw any line between the two. It would be very difficult to fix upon any precise standard of scarcity or abundance: another botanist might give a considerably different estimate; and the same species must vary in abundance in different parts of so large an area. No great accuracy is therefore to be expected in the numbers. The introduced plants are of course left out of view: and the whole following statement may be taken to refer rather to the country in its wild state, than as now gravely modified in its botanical features by the agency of civilized man.

1. *As to the area occupied*, I compute that there are of

	Exogenæ	Endogenæ excl. Cyperaceæ and Gramineæ.	Cyperaceæ and Gramineæ.	Total.
1. Very local species, - -	228	26	44	298
2. Species of small or narrow range, compared with the extent of country embraced in the Flora, - - - - -	542	92	144	778
3. Species ranging over an area equal to between $\frac{1}{8}$th and $\frac{3}{4}$ths of our territory, i. e. all not included in No. 1, 2 and 4. - -	397	49	92	538
4. Species of widest range over our territory. - -	323	59	95	477

2. *As to the abundance of individuals* where the species occurs:

	Exogenæ.	Endogenæ.	Total.
1. Very scarce, - - - - - -	11	10	21
2. Not abundant, - - - - -	66	20	86
3. Moderately abundant (as far as known), - - - - -	493	47	540
4. Very abundant, - - - -	920	524	1444

To exhibit the distribution according to the genera, or even the natural orders, would require too much room.

In the last table I have not distinguished the Glumaceous from the Non-Glumaceous *Endogenæ*, because, in fact, all our *Gramineæ* and *Cyperaceæ* are abundant in individuals wherever they occur, so that I have thrown in the whole 375 under the fourth head; although probably one quarter of them might be better placed under the third. Of the 20 *Endogenæ* which are not abundant in their habitats, but yet not very scarce, all but four are *Orchidaeceæ*. The 21 scarcest species are

Exogenæ.	*Endogenæ.*
Sibbaldia procumbens.	Limnobium Spongia.
Saxifraga rivularis.	Platanthera rotundifolia.
Nardosmia palmata.	Listera cordata.*
Coreopsis bidentoides (a very obscure plant).	" australis.
Gnaphalium supinum.	" convallarioides.
Nabalus Bootii.	Calypso borealis.
Arctostaphylos alpina.	Tipularia discolor.
Pterospora Andromedea.	Liparis liliifolia.*
Schweinitzia odorata.	" Lœselii.*
Hemianthus micranthemoides (?)	Aplectrum hyemale.*
Obolaria Virginica.*	

Five of the plants in the first column (printed in *italics*) are alpine, and with us peculiarly local, species; and four of the remainder are very local, the two of considerable range being *Pterospora Andromedea* and *Obolaria Virginica*. Of the ten species in the second column all but one are *Orchidaceæ*, and all but one (*Aplectrum*) either very local species or of narrow range. None of the 21 species are known at many stations within our limits; only five of them (marked with an asterisk) have probably been collected at more than half a dozen places; and most of the rest are known at only two or three stations.

And generally, that our species of widest range are most abundant in individuals is shown by the fact, that, of our 477 most widely spread species, 420 (or 96 per cent) are marked as belonging to this category. These are distributed among the natural orders as follows.

Number of Species of each Natural Order which are both of widest Geographical Range in the Northern United States, and most abundant in Individuals where they occur.

Ranunculaceæ,	12	Anacardiaceæ,	5
Berberidaceæ,	1	Vitaceæ,	4
Cabombaceæ,	1	Rhamnaceæ,	1
Nymphæaceæ,	2	Celastraceæ,	1
Papaveraceæ,	1	Aceraceæ,	2
Fumariaceæ,	1	Polygalaceæ,	2
Cruciferæ,	5	Leguminosæ,	14
Violaceæ,	6	Rosaceæ,	20
Cistaceæ,	2	Lythraceæ,	1
Droseraceæ,	1	Onagraceæ,	5
Hypericaceæ,	5	Cucurbitaceæ,	1
Caryophyllaceæ,	4	Crassulaceæ,	1
Tiliaceæ,	1	Saxifragaceæ,	1
Oxalidaceæ,	1	Umbelliferæ,	6
Geraniaceæ,	2	Cornaceæ,	2
Balsaminaceæ,	2	Caprifoliaceæ,	4

Rubiaceæ,	7	Urticaceæ,	6
Compositæ,	57	Plantanaceæ,	1
Lobeliaceæ,	3	Juglandaceæ,	3
Ericaceæ,	6	Cupuliferæ,	7
Aquifoliaceæ,	1	Betulaceæ,	2
Primulaceæ,	2	Salicaceæ,	11
Lentibulaceæ,	1	Coniferæ,	2
Orobanchaceæ,	1		
Scrophulariaceæ,	15	Araceæ,	2
Verbenaceæ,	1	Typhaceæ,	3
Labiatæ,	11	Lemnaceæ,	3
Borraginaceæ,	2	Naiadaceæ,	6
Hydrophyllaceæ,	1	Alismaceæ,	3
Convolvulaceæ,	2	Hydrocharidaceæ,	2
Solanaceæ,	1	Orchidaceæ,	7
Gentianaceæ,	1	Amaryllidaceæ,	1
Apocynaceæ,	2	Iridaceæ,	2
Asclepiadaceæ,	6	Dioscoreaceæ,	1
Oleaceæ,	2	Smilaceæ,	3
Phytolaccaceæ,	1	Liliaceæ,	4
Polygonaceæ,	10	Melanthaceæ,	2
Lauraceæ,	1	Juncaceæ,	8
Saururaceæ,	1	Pontederiaceæ,	2
Ceratophyllaceæ,	1	Cyperaceæ,	53
Callitrichaceæ,	1	Gramineæ,	39
Euphorbiaceæ,	3		
Exogenæ,	279,	Endogenæ,	141 = 420

These 420 species must form the most conspicuous elements of our flora taken as a whole; and if there were room to spare, it would be worth while to enumerate them. If we arrange the families they belong to in the order of the number of these common species they respectively contain, the largest ten will stand as follows:—

Compositæ,	57	Leguminosæ,	14
Cyperaceæ,	53	Ranunculaceæ,	12
Gramineæ,	39	Labiatæ,	11
Rosaceæ,	20	Salicaceæ,	11
Scrophulariaceæ,	15	Polygonaceæ,	10

On comparing this with the table on p. 213 of vol. 22, we perceive that the orders hold nearly the same relative rank, except that the *Rosaceæ* and *Leguminosæ* have interchanged places (the former having a much larger number both of wide-spread and of social plants than the latter); that the *Ericaceæ* and *Orchidaceæ* fall to a low position, and that in their stead the *Salicaceæ* and the *Polygonaceæ* are among the largest orders. This is owing to the general absence of *Ericaceæ* in our open or prairie country west of the Alleghanies, and to the small number of *Orchidaceæ* which endure much diversity of climate.

Moreover, seven orders comprise half of these plants; whereas it takes between nine and ten orders to embrace a moiety of all our indigenous species.

The species which I have counted as those of widest range are simply those which are known to occur along or not far distant from our frontiers on the four sides, without reference to the frequency of their occurrence within the area. And the species designated as very abundant in individuals are merely those which occur copiously wherever the species occurs at all, in a congenial station, even if only a single station be known, as is the case with *Sullivantia Ohioensis*, *Calamagrostis Pickeringii*, &c. It might well happen, therefore, that some of the foregoing 420 species of widest range within our territory, and of greatest abundance in their localities, should after all be uncommon plants, on account of the sparseness of the habitats. And on turning over the lists, indeed, I find that they contain species of very various degrees of abundance, above a certain point (which I am unable to express numerically), and of quite various degrees of frequency of occurrence, i. e. of the number and extent of the stations, throughout the country. But so true is it as a general rule, that species of wide range in our country are species of frequent occurrence, that I have not noticed any strongly marked exceptions to it in the lists from which the foregoing statements were deduced, viz., those which are also abundant in individuals,—meaning, of course, of frequent occurrence at the proper stations for each species; for very few plants are sown broad-cast over the land, and few occur under any wide diversity of physical circumstances. I was inclined to draw up a catalogue of those widely ranging species which are most abundant generally throughout our district, and another of the least abundant. But I find, on trial, that this demands a critical consideration which I have not time to give, as well as a particular knowledge of the details of the vegetation of the different parts of so wide a country, which I am far from possessing. The area is much too large, and the climate, soil, &c., too diversified for the proper elaboration of such a mass of details. I conjecture that about two-thirds of the foregoing 420 species would find a place in a list of the 500 commonest plants of each of the eighteen States within our limits.

It may be mentioned that about 350 of these both widespread and abundant species are herbs, 42 are shrubs or woody vines, and 28 may be reckoned as trees. The latter, forming as they do an important feature in the vegetation of a country which was naturally for the most part forest-clad, are here enumerated:—

Tilia Americana.
Acer rubrum.
" dasycarpum.
Prunus Americana.
" Virginiana.
" serotina.
Cratægus coccinea.
" tomentosa.
Amelanchier Canadensis.
Fraxinus Americana.
" viridis.
Sassafras officinale.
Ulmus Americana.
Celtis occidentalis.
Platanus occidentalis.
Carya alba.
" glabra.
" amara.
Quercus obtusiloba.
" alba.
" coccinea.
" rubra.
Carpinus Americana.
Ostrya Virginica.
Salix nigra.
Populus tremuloides.
Pinus mitis.
Juniperus Virginiana.

The foregoing list, after all, includes none of our *most social* forest trees. The latter I should rank in the following order as to sociability:—

Abies nigra and alba.
Abies balsamea and Fraseri.
Thuja occidentalis.
Larix Americana.
Abies Canadensis.
Pinus Strobus.
Pinus Tæda, rigida, and the rest.
Taxodium distichum.
Cupressus thyoides.
Salix nigra.
Populus monilifera and angulata.
Fagus ferruginea.
Fraxinus sambucifolia.
Betula alba.
" papyracea.
Acer saccharinum.
Quercus nigra, obtusiloba, aquatica, &c.

The most social of the larger shrubs, rising occasionally to small trees, are:

Rhododendron maximum.
Kalmia latifolia.
Salix, various species.
Alnus incana and serrulata.
Myrica cerifera.
Quercus ilicifolia.
Rhus typhina, glabra, and venenata.
Amorpha fruticosa.
Zanthoxylum Americanum.
Pyrus Americana.
Cephalanthus occidentalis.
Vaccinium corymbosum.
Clethra alnifolia.
Azalea viscosa, &c.

Characteristics of the Vegetation of the principal Districts comprised in our Flora.

The main botanical districts, into which the territory embraced in our Flora is naturally divided, are three, with two subordinate ones. These are unmistakably defined by the general features of the country, and pretty strongly marked by their vegetation. They are,

1. The Southeastern low border (naturally wooded).
2. The great Middle and Northern Wooded Region.

3. The Western Unwooded or Sparsely wooded Region, characterized by prairies, oak-openings, &c. To which are appended,
4. The Alpine and Subalpine Region, forming a few isolated patches in the second district.
5. The line of Sea-coast, or Maritime District.

I. *The Southeastern District.*—If, from the intersection of the 80th parallel of longitude with the southern boundary of Virginia a line be drawn northeast to Washington and the city of New York, it will very nearly mark the inland limits of this district, except that a narrow prolongation of it, somewhat modified in character, skirts the coast as far as to Cape Ann, and vanishes at the southern point of Maine. The Pine-Barrens of New Jersey represent this district fully. Its prevalent forest-growth consists of Pitch Pines and Oaks, especially of the Spanish Oak, Post Oak, and Black Jack, and in low grounds of Red and White Maples and Birch. Few of the forest trees probably were ever large and stately, at least at the north. The characteristic trees and largest shrubs are *Pinus rigida* and *P. inops*, and at the south *P. Tæda* and *Taxodium distichum*, *Cupressus thuyoides*, *Betula alba* and *nigra*, *Castanea pumila*, *Quercus falcata*, *Phellos*, and *aquatica*, *Ilex opaca* (which at the south passes inland to the flanks of the mountains), *Liquidambar styraciflua*, *Chionanthus Virginica*, *Itea Virginica*, *Clethra alnifolia*, *Azalea viscosa*, *Cratægus parvifolia*, *Acer dasycarpum*, *Magnolia glauca*, and at the south *Persea Carolinensis*, with several southern trees (such as *Quercus virens*, *Olea Americana*, &c.) which however occur only on the coast of Virginia. Other most characteristic shrubs are *Gaylussacia dumosa* and *frondosa*, *Leucothoë racemosa*, and at the south *L. axillaris*, *Andromeda Mariana*, *Ilex* (*Prinos*) *glabra*, *Corema Conradi* and *Comptonia asplenifolia* at the north, and *Myrica cerifera* along the whole line of coast. The two species of *Ascyrum* and *Smilax laurifolia* may also be mentioned.

As to herbs, out of about 120 either wholly peculiar or otherwise characteristic species, I must barely mention *Drosera filiformis*, *Polygala lutea* and *ramosa*, *Clitoria Mariana*, three species of *Rhexia*, *Opuntia vulgaris*, *Eryngium Virginianum*, *Eupatorium leucolepis*, *resinosum*, *album* and *aromaticum*, *Aster Radula*, *surculosus*, *spectabilis*, and especially *A. concolor*, with *Solidago virgata*, *puberula*, and *pilosa*, four species of *Chrysopsis*, *Coreopsis trichosperma*, *Nabalus virgatus*, *Utricularia inflata*, *clandestina*, *striata*, *purpurea* and *resupinata*, *Schwalbea Americana*, *Pyxidanthera barbulata*, *Stylisma Pickeringii*, four species of *Sabbatia*, *Euphorbia Ipecacuanha*, *Gymnadenia flava* and *Platanthera cristata*, *Lachnanthes*, *Lophiola*, *Yucca filamentosa*, *Xerophyllum* and *Helonias bullata*, *Tofieldia pubens*, *Narthecium Americanum*, and *Amphicarpum*, the last two peculiar to the Pine-barrens of New Jersey.

II. *The Middle and Northern Wooded District* takes in the whole breadth of our territory along its northern boundary, but narrows rapidly towards the south into a wedge-like shape. A line drawn from Fond du Lac to the western end of Lake Erie, and thence south to the Tennessee line, would serve tolerably well for its western boundary. This vast tract naturally divides into three provinces, viz: the *Southern*, comprising all south of Pennsylvania and the Ohio River; the *Northeastern*, comprising all north and east of Pennsylvania, and all except the southwestern corner of that state; and the *Northwestern*, including all west of Pennsylvania. With some local and inconsiderable exceptions, this tract was originally covered with dense forest, composed in the higher and cooler or moister portions partly of Spruces, and in the valleys of White Pines, and partly of Beech, Maples and other deciduous trees, or in sandy tracts of Pitch Pines, Post Oaks, &c., and in the lower portions with stronger and deeper soil, of several kinds of Oak, of Hickories, Chestnut, &c.

The most characteristic and important tree of the whole region doubtless is, or rather was, *Pinus Strobus*, the White Pine, which everywhere at the north once filled the principal intervales with a most stately growth. Other prominent forest-trees of the whole district are the White, Red, Scarlet and Chestnut Oaks, the Chestnut, the Beech, three Hickories (*Carya alba*, *glabra* and *amara*), the Butternut, the White and Slippery Elm, the White, Red and Green Ash, the Sugar Maple, and of course the widespread Red Maple, as well as the common Lime-tree or Basswood; also, as we verge southward or westward, the Tulip-tree and the Cucumber-tree. Trees which belong wholly or characteristically to the southern province are *Abies Fraseri*, *Magnolia Umbrella* and *Fraseri*, *Asimina triloba*, *Tilia heterophylla*, *Negundo*, the Sweet Buckeye, the Common and the Clammy Locust-trees, the Red-bud, the Sorrel-tree, and *Rhododendron maximum;* which last, with *Kalmia latifolia*, rising into small trees in many places, form almost impassable thickets along the steep sides of the Alleghany Mountains. The Ohio Buckeye (*Æsculus glabra*), the Kentucky Coffee-tree, the Honey Locust, the American Crab-apple, the Black Walnut and *Carya sulcata* are characteristic of the western province. *Pinus resinosa*, *Abies balsamea*, *Canadensis*, *nigra* and *alba*, *Larix Americana*, *Thuja occidentalis*, with *Betula papyracea*, *excelsa* and *lenta*, *Quercus palustris*, the Black Ash, and among small trees, *Pyrus Americana*, *Prunus Pennsylvanica*, *Acer Pennsylvanicum*, and *Rhus typhina*, are characteristic northern species. I must not stop to enumerate the characteristic shrubby and herbaceous plants.

III. *The Western District*, comprised between the boundary last mentioned and the Mississippi River, consists of glades, 'Oak-openings,' 'barrens,' and at length of prairies or open

plains. Its trees, where these occur, are principally some of those of the foregoing districts, especially *Quercus nigra, imbricaria, rubra* and *obtusiloba* with *Q. macrocarpa, Carya olivæformis,* and along rivers the Cotton-wood, Blue Ash, &c. I can hardly enumerate any peculiar shrubs of the district, excepting *Amorpha canescens,* which is local this side of the Mississippi. The characteristic herbs of the prairies, &c., would seem to be *Compositæ,* especially Helianthoid Compositæ, such as *Helianthus rigidus, lætiflorus, occidentalis, mollis, hirsutus,* and in the river bottoms *H. doronicoides, Actinomeris helianthoides, Coreopsis aristosa* and *palmata, Echinacea purpurea* and *angustifolia,* and especially *Silphium laciniatum* (the Compass plant), *terebinthinaceum, integrifolium,* &c.; to which may be added *Cacalia tuberosa, Nabalus racemosa, asper* and *crepidineus, Ambrosia bidentata* and *psilostachya, Veronica fasciculata, Liatris pycnostachya, Eupatorium serotinum, Solidago Ohioensis, Riddellii,* and *Missouriensis, Aster oblongifolius, azureus, turbinellus,* and *sericeus.* As herbs peculiar to this district and its immediate borders, I may mention *Isopyrum biternatum, Delphinium tricorne, Stylophorum diphyllum, Hypericum sphærocarpum* and *dolabriforme, Psoralea Onobrychis* and *stipulata, Gillenia stipulacea, Geum vernum, Gaura filipes, Ludwigia polycarpa, Erigenia bulbosa, Solidago Shortii* and *rupestris, Monarda Bradburiana, Seymeria macrophylla, Lithospermum latifolium, Phlox bifida, Gentiana puberula, Platanthera leucophæa, Cypripedium candidum, Trillium recurvatum* and *nivale.* The only Grasses I know which are peculiar to the district, and not found east of the Alleghanies, are *Poa sylvestris, Diarrhena Americana,*—neither of them prairie-grasses,—and *Lepturus paniculatus,* which mainly belongs to salt-licks and to the dry plains farther west.

In fact,—looking at North American botany comprehensively,—this district cannot claim to be distinguished as a separate one. It is only a broad border along which the great naked plains of the west and the eastern forest region meet and blend through the most diversified gradations. And so, likewise our southeastern district is only a narrow extension of the botany of the warm-temperate region of the Southern United States, prolonged northward upon the low coast, just as the botany of our cool-temperate region is prolonged southward along the Alleghanies.

IV. *The Alpine and Subalpine District* has been sufficiently illustrated already (vol. 22, pp. 207, 230, vol. 23, p. 62).

V. *The Maritime District* is inhabited by the following 60 species.

Ranunculus Cymbalaria.
Cakile Americana.
Hudsonia tomentosa.
Lechea thymifolia.
Honkenya peploides.
*Spergularia rubra.
Sesuvium Portulacastrum.
*Hibiscus Moscheutos.

Lathyrus maritimus.
*Prunus maritima.
Crantzia lineata.
Ligusticum Scoticum.
Archangelica peregrina.
*Aster flexuosus.
* " linifolius.
*Solidago sempervirens.
Pluchea camphorata.
Baccharis halimifolia.
*Iva frutescens.
Borrichia frutescens.
Plantago maritima.
*Statice Limonium.
Glaux maritima.
Limosella aquatica.
Gerardia maritima.
Mertensia maritima.
Sabbatia calycosa.
" stellaris.
" gracilis.
" chloroides.
Blitum maritimum.
*Atriplex hastata.
*Obione arenaria.
*Salicornia herbacea.
Salicornia mucronata.
" ambigua.
*Chenopodina maritima.
*Salsola Kali.
Euxolus pumilus.
*Acnida cannabina.
*Rumex maritimus.
*Euphorbia polygonifolia.
*Zostera marina.
*Ruppia maritima.
Triglochin palustre.
" maritimum.
Juncus maritimus.
" bulbosus.
Scirpus Olneyi.
* " maritimus.
Vilfa Virginica.
Calamagrostis arenaria.
Spartina polystachya.
* " juncea.
* " stricta.
Glyceria maritima.
" distans.
*Brizopyrum spicatum.
Uniola paniculata.
*Hordeum jubatum.

A little less than half of these maritime species occur also in Europe; and one not found in Europe (*Ranunculus Cymbalaria*) occurs in Northern Asia. Four of them are exclusively southern, not extending northward to the Delaware Bay; viz. *Borrichia frutescens*, *Sabbatia calycosa*, *Vilfa Virginica*, and *Uniola paniculata*, and nine others (including *Juncus maritimus*) are prevailingly southern, and find their boreal limit south of Massachusetts Bay. Four species (*Ligusticum Scoticum*, *Archangelica peregrina*, *Glaux maritima*, and *Mertensia maritima*) are exclusively northern, not occurring south of New England; and 23 species (those with an asterisk prefixed) range along the coast from Maine to Virginia, or nearly so. Several maritime species still linger on the shores of our Great Lakes, mementoes of their former saltness, viz. *Hudsonia tomentosa*, *Cakile Americana*, *Lathyrus maritimus*, *Calamagrostis arenaria*, and *Hordeum jubatum*; while *Ranunculus Cymbalaria*, *Glaux maritima*, &c. occur in saline soil far beyond the Mississippi, and the former, with *Hibiscus Moscheutos*, *Salicornia herbacea*, *Scirpus maritimus*, and the two species of *Triglochin*, spring up at most of our salt springs in the interior of the country, as at Salina, New York. Singularly enough, what seems to be truly *Triglochin maritimum* (the *T. elatum* of Nuttall) is of no uncommon occurrence throughout Western New

York, Ohio, Wisconsin, &c., in high sphagnous bogs which have not the least trace of saltness.

Only one of our maritime plants is a true shrub, viz. *Baccharis halimifolia*. *Iva frutescens* is more or less woody; and *Hudsonia tomentosa* is a heath-like under-shrub: the rest are herbs.

On the whole, I should say that the range of our maritime plants through degrees of latitude is not sensibly greater than that of our herbaceous species generally.

The Prominent Characteristics of the Flora of the Northern United States.

To answer the question as to what are the leading characteristics of the vegetation of the Northern United States, taken as a whole, we should have to consider, first: What are the more remarkable peculiarities of our flora, as discovered by the instructed botanist with the whole field systematically displayed to his mental view; and secondly, what are the plants or the forms of vegetation which, by their abundance or their prominence, impart to our flora its dominant features. The first is a matter of deduction from a variety of facts, many of which would never arrest the attention of the casual observer: the second relates to points which would most attract the notice of the passing botanical traveller or the ordinary observer. The answer to the former no less than to the latter enquiry, would depend upon the point of view. To the traveller from our Southern States, or from the great plains of the West, the novel features of our vegetation are those which it has in common with Europe. To the European visitor the striking peculiarities are those which we share with the southern part of the country, and these would increase in prominence as he proceeded southward and westward. And, in forming his idea of a flora, the botanist naturally, if not inevitably, takes that of Europe as his standard of comparison.

In comparing, as the botanist naturally would, our flora with that of Northern and Western Europe, the following would appear to be leading characteristices.

1. Our comparative richness in ordinal types;—our flora having, as already remarked (vol. xxii, p. 216), 26 orders which are absent from that of Europe, while the latter (exclusive of the Mediterranean basin) has only seven orders which are wanting here.

2. The prevalent subtropical character of our extra-European orders;—which has been already referred to, and which will be manifest to the botanist inspecting the list of such orders given in a former article (vol. xxii, p. 215).

3. Our richness in species of woody plants, and especially of trees; as already alluded to (p. 84). This will strikingly appear

from a comparison of our flora with an equivalent European one,—with the German flora, for example. In Koch's *Flora Germanica* (excluding the Adriatic region), I count 60 indigenous species of trees, belonging to 27 genera, and comprised in 14 orders. In our own *Flora of the Northern United States*, adopting the same estimate as to what constitutes a tree, I count 132 trees, in 56 genera, and belonging to 25 orders; as follows:—

Magnoliaceæ,	2	genera,	and	6	species	of	trees.
Anonaceæ,	1	"	"	1	"	"	
Tiliaceæ,	1	"	"	2	"	"	
Camelliaceæ,	1	"	"	1	"	"	
Anacardiaceæ,	1	"	"	1	"	"	
Sapindaceæ,	3	"	"	8	"	"	
Leguminosæ,	6	"	"	7	"	"	
Rosaceæ,	4	"	"	15	"	"	
Hamamelaceæ,	1	"	"	1	"	"	
Araliaceæ,	1	"	"	1	"	"	
Cornaceæ,	2	"	"	4	"	"	
Caprifoliaceæ,	1	"	"	1	"	"	
Ericaceæ,	2	"	"	2	"	"	
Aquifoliaceæ,	1	"	"	1	"	"	
Ebenaceæ,	1	"	"	1	"	"	
Sapotaceæ,	1	"	"	2	"	"	
Oleaceæ,	3	"	"	8	"	"	
Lauraceæ,	2	"	"	2	"	"	
Urticaceæ,	4	"	"	8	"	"	
Platanaceæ,	1	"	"	1	"	"	
Juglandaceæ,	2	"	"	9	"	"	
Cupuliferæ,	5	"	"	21	"	"	
Betulaceæ,	1	"	"	5	"	"	
Salicaceæ,	2	"	"	7	"	"	
Coniferæ,	7	"	"	18	"	"	

The only natural order containing trees in the German flora and not in ours is the *Rhamnaceæ;* the only order in which the German flora exceeds ours in arboreous genera is that of *Betulaceæ* (which comes from our not counting any of our Alders as trees); the only order in which the German flora has more species of trees than ours is that of the *Salicaceæ* (10 to 7), we counting but one truly arboreous indigenous Willow. On the other hand, our flora surpasses the German not only in the twelve additional orders (one of which is represented by nine species and another by six), but also having a greater number of species in ten out of the thirteen orders common to the two countries, and of genera likewise in all but three of them. That is, we possess of

Sapindaceæ (including Hippocastanaceæ and Aceraceæ),	2	more	genera	and	3	more	species	of trees.
Leguminosæ,	5	"	"	"	6	"	"	"
Rosaceæ,	0	"	"	"	2	"	"	"

Cornaceæ,	1	more	genus	and	3	more	species of trees.
Ericaceæ,	1	"	"	"	1	"	"	"
Oleaceæ,	2	"	"	"	6	"	"	"
Urticaceæ,	2	"	"	"	5	"	"	"
Cupuliferæ,	0	"	"	"	11	"	"	"
Betulaceæ,	0	(—1)	"	"	3	"	"	"
Coniferæ,	3		"	"	10	"	"	"

4. Our flora, it may be seen, accordingly predominates in its species of Pine, Fir, Oak, Birch, Elm, Ash, arboreous as well as shrubby *Cornaceæ, Cratægi*, and of arboreous *Leguminosæ;* and its characteristic trees are the *Taxodium*, the Overcup, Willow and Chestnut-Oaks, the Hickories and Walnuts, the Planer-tree and two *Sapotaceæ*, which barely reach us from the South, the Persimmon, the Gum-trees (both *Nyssa* and *Liquidambar*), the Common and Honey Locusts, *Cladrastis*, and the Kentucky Coffee-tree, the Negundo and three species of Buckeye, the Sumac, the Loblolly Bay of our southeastern border, the Papaw-tree, the Tulip-tree, and our five species of Magnolia. We might have added *Zanthoxylum*, but no Prickly Ash fairly forms a tree within our geographical limits.

5. Our flora is equally rich in shrubs, of a great variety of families, especially in those which make an undergrowth in forests; and, among them, in *Vaccineæ*, *Andromedeæ* and *Rhodoreæ*, while it has no *Arbuteæ* rising above the surface of the ground, and no *Ericeæ* or Heaths at all.

6. It is also rich in *Compositæ*, especially Helianthoid *Compositæ*, *Eupatorinæ*, Asters, and Solidagoes, in the latter genera outnumbering any other region; but is poor in *Anthemideæ*, true *Senecioneæ*, and in *Cynareæ*, and especially so in *Cichoraceæ*.

7. It has an unusual number of *Cyperaceæ*, which is owing partly to the remarkable number of extra-European genera, and partly to the number of species of *Cyperus*, *Rhynchospora*, and *Carex*.

8. From the position of *Rosaceæ* on the list of the larger orders, our flora would be supposed to be unusually rich in that order also; but this result happens in consequence of our remarkable comparative poverty in *Cruciferæ*, *Umbelliferæ*, *Labiatæ*, and *Caryophylleæ*. Other orders in which our flora is much deficient, as compared with Europe, are *Borraginaceæ*, *Campanulaceæ*, *Liliceæ* in the larger sense, and *Iridaceæ*, *Crassulaceæ*, *Chenopodiaceæ*, *Primulaceæ*, and *Geraniaceæ*. Those in which we are correspondingly rich are *Asclepiadaceæ*, *Polemoniaceæ*, *Smilaceæ*, *Melanthaceæ*, *Araliaceæ*, and *Onagraceæ*.

9. To present the elements of the 26 orders represented in our flora but wanting in that of Europe, and in which characteristic features are necessarily comprised, would still further extend

an article already inconveniently protracted. The botanist can readily gather the needful details respecting them, and respecting our extra-European genera generally, from the data given in a former article.

As regards the plants most striking and important in the physiognomy of our vegetation, the first rank is undoubtedly held by the trees of social growth; and of these the principal are *Coniferæ*. The characteristic tree of the proper Northern States is, therefore, *Pinus Strobus*. This, the tallest and once the most plentiful of our trees, when the country lay in all the wildness of nature, must have given the dominant feature to a great part of the landscape. White Pines may probably be distinguished by their port and aspect from a greater distance than any other of our forest-trees, except perhaps the *Taxodium* of our Southern "Cypress" swamps, and the long-leaved Pine which so strikingly marks a belt of low and barren country stretching from the southeastern borders of Virginia to the Gulf of Mexico and the Mississippi.

Pinus Tæda near our southern limits, and, more northward, *P. rigida* and the other Pitch Pines, give a predominant feature to the "pine-barrens" of the Northern States.

Our Arbor Vitæ (*Thuja occidentalis*) of intensely social growth, is the physiognomic tree of our cold swamps at the North, and of Canada. Large tracts of cold and poor marshy land at the north, and on the mountains, are occupied with the well-marked Balsam Fir, or, where less damp, with the more sombre and stiff Black Spruce, or, with the closely related White Spruce; the latter, however, only along our northern frontier. *Abies Fraseri* replaces the common Balsam Fir in the Alleghanies south of Pennsylvania, and has just the same aspect. Hemlock Spruce woods (*Abies Canadensis*) cover hill-sides and sharp ridges of a light and thin soil, where water never stands, throughout the northern part of the country, with a truly characteristic forest-growth. Larch or "Tamarack" swamps are strongly marked in aspect, but are never large.

No other species of forest trees that I know monopolize the ground in so marked a manner, and impress their single features upon a tract of country. The Beech woods of elevated tracts, and the Sugar Maple in richer and lower ground, make the nearest approach to it: but ordinarily our woods of deciduous trees consist of a mixture of several species, in which different kinds predominate according to the situation. In enumerating, as I have done farther back, the trees most characteristic of our three principal districts, I have mentioned those which more than any other give character to our arboreous vegetation. As trees which possess marked individuality, and which may be known from far, I barely mention the common American Elm of our

intervales, the Button-wood or *Platanus* on the banks of rivers and streams, the Sugar Maple, the various Hickories, the Black Walnut, and several Oaks, the White and the Paper Birch, conspicuous from the ghastly white bark of their trunks, as well as by their light and handsome foliage, the Sassafras, the Cucumber-tree, the Tulip-tree, the Honey Locust with its remarkably light and feathery foliage, and the *Gymnocladus* or Kentucky Coffee-tree, with its thick and stout branchlets, and its remarkably decompound foliage, rendered the more striking in aspect by the oblique or almost vertical position which the leaflets generally assume.

Of trees conspicuous in blossom, *Cornus Florida*, the two Umbrella-leaved Magnolias, the Locust, the *Cladrastis*, the Red-Bud, and the Crab-Apple hold the first place, and the Umbrella-trees with their rose-colored cones are equally conspicuous in fruit. The Loblolly-Bay, *Rhododendron maximum*, and the *Chionanthus* or Fringe-tree are equally showy, but they are generally shrubs rather than trees.

Considering our great variety of trees and shrubs, there is a remarkable absence of broad-leaved evergreens. The American Holly is our only tree of the sort of considerable size, and that is not a common one. Of large shrubs or small trees, *Rhododendron maximum* and *Kalmia latifolia*—our "Laurels,"—are our principal and truly characteristic evergreens, as they are among the most social of our woody plants.

The herbaceous plants which most strike the eye are of course the *Compositæ*, especially toward the close of summer, when golden Solidagoes and purple, blue, and white Asters are everywhere conspicuous. Of vernal flowers,—peculiarly delightful to us after a winter which destroys all herbaceous vegetation,—the most common species which strike the eye over the whole country (in their appropriate stations) are *Caltha palustris, Aquilegia Canadensis, Anemone nemorosa,* with *Thalictrum anemonoides, Sanguinaria Canadensis, Saxifraga Virginiensis, Viola cucullata, sagittata* or one or two other stemless Violets, *Claytonia,* one or the other species, *Oldenlandia* (*Houstonia*) *cærulea, Senecio aurens, Smilacina bifolia, Erythronium Americanum, Uvularia sessilifolia,* and, a little later, *Geranium maculatum.*

The part which introduced plants take in our flora, with some kindred topics, must be considered in a future article.

Art. XXXVIII.—*On the Meridian Instruments of the Dudley Observatory;* by Dr. B. A. Gould, of Cambridge.

Proceedings of the American Association for the Advancement of Science at Albany, July, 1856.

Mr. Gould described the meridian-circle and transit-instrument, now nearly completed for the Dudley Observatory, and gave some account of the principles adopted in their construction.

The meridian instruments now in use in the several observatories of the world may be classified in two divisions,—which may be designated as the German and the English styles,—and perhaps be justly described, the one as the instrument of the engineer, the other as that of the artist. For the former the circles are large and massive, frequently having a diameter equal to the entire focal length of the attached telescope; in the latter they are smaller and slighter. The new transit-circle of Professor Airy, at Greenwich, typifies the English style, and this instrument, with its counterpart at the Cape of Good Hope, presents the merits in the most conspicuous and impressive form. It is of iron, cast in a single piece; incapable of reversal, for which the observation of collimators is substituted; without a striding or hanging level, this apparatus being superseded by observations of the meridian thread as reflected from the surface of mercury; the circle is eight feet in diameter, and read by diverging microscopes firmly imbedded in a massive pier; and the pivot-forms are investigated by means of a collimating apparatus, of which the axis of rotation itself forms a part.

The instruments of the German school are of an entirely different order,—lighter and more mobile. Their circles are small in comparison with the length of the tube; the microscopes are supported upon a frame concentric with the axis, and form one system, the position of which is known by means of an attached level, whose indications furnish a correction to be applied to the mean of their several readings. The level is used, indeed, whenever its use is possible, and a great part of the precision of the results of observation is dependent upon the delicacy with which this highly trusted instrument may be constructed and used. Frequent reversals of the instrument are deemed indispensable: and in general the structure is devised with a view to easy, rapid and frequent changes in the relative position of all those parts which may be rendered movable. To sum up,—the one class of instruments is designed for securing absolute uniformity of circumstances in all observations; the other, for attaining as great diversity of circumstance as is consistent with the retaining of the same degree of accuracy.

The meridian-circle for the Dudley Observatory has been ordered of Messrs. Pistor and Martins, of Berlin, and in its form and the fundamental principles adopted, my aim has been to avoid the prejudices of education and the prepossessions of taste, and if possible to exercise an eclectic judgment, using however the greatest care to shun such a composite form as would impair the unity of idea, and fail of the preponderant merit which both the English and the German forms may claim, in being consistent developments of their fundamental idea.

All this seemed not impossible; nor indeed did it appear beyond attainment to combine, with such an eclectic form, sundry new and by no means unimportant additions. This has been the endeavor, and it remains to be seen how sound may have been the foundation for these hopes and expectations.

The object-glass is from material furnished by Messrs. Chance Brothers, of Birmingham, and made under the supervision of Mr. Masselin. It was my earnest desire that it might be ground and worked into form by some one of our own accomplished artists, but the Berlin mechanicians were unwilling to entertain any proposition of the kind,—desiring to take the whole responsibility, if any,—and were so strenuous that I refrained from pressing the matter. The clear aperture is ninety French lines; the focal length, ten English feet.

Both circles are divided, and capable of rotation round the axis, and they are read by means of four microscopes firmly set in each pier,—horizontal, not converging, although the divided silver limb is slightly oblique to prevent the dazzling image of the lamp from blinding the observer's eye. The piers being two feet in thickness, and the microscopes read from the outer side, these microscopes are not far from twenty-five inches in length, —a circumstance which gives rise to various not unimportant disadvantages; but the ingenuity and skill of Mr. Martins have surmounted the chief of these, the large amount of expansion and contraction of the metal due to changes of temperature, with great succes, by leaving the metal tubes free to extend or recede without hindrance, and without affecting either the distance of the lenses or their fixity in the stone.

To obviate the chief disadvantages of attaching the microscopes to the piers, namely, those arising from the unequal changes in the piers themselves, these will be coated with oil, or some other preparation for excluding moisture, wound around with list or baize, and then encased in wood. With these precautions, I am very confident that we are justified in awaiting from this more massive construction greater advantages than would be derived from the metallic connection of the microscopes, although continually subjected to scrutiny by means of the attached ether-level.

The circles are three feet in diameter, and entirely protected on the outer side by the piers. They are of the form which long experience has recommended to Messrs. Pistor and Martins as the best,—not too heavy at the rim, and with radial arms thickening in both dimensions towards the centre. The screen-tubes for the microscopes draw back automatically as soon as the counterpoises are relieved of a portion of their burden, and it is thus possible to have them very close to the circles, when in use, without incurring any danger of injuring the graduation when the instrument is lifted for reversal.

The eye-piece has a vertical as well as a horizontal motion; and the diaphragm, which is of course adapted for chronographic observation, is provided with both a horizontal and a vertical micrometer,—the former being especially intended for the observation of polar stars, according to the method recently adopted in the Paris Observatory, and which Professor Bache had investigated in 1849.

The method of Hansen for measuring and eliminating the effect of flexure comes from authority too high, and commends itself too strongly, to justify us in lightly setting it aside. But advantages entirely incompatible with its employment presented themselves in such number as to induce me to accede to the earnest recommendation of the artist, and abandon the original plan of interchangeable eye-piece and object-glass. Some of the decisive arguments, briefly expressed, are the following. It is only when the most absolute symmetry has been attained in every part of the tube and its accessory parts, that the flexure is absolutely determined in this manner; otherwise, we obtain the measure of an ideal, not a real, flexure. Furthermore, not only is the formula which attributes the maximum flexure to the horizontal position, and makes the flexure in other positions a simple function of the altitude, not trustworthy, but I will not hesitate to go farther, and, paradoxical as it may appear, to express my decided conviction, that the flexure is not necessarily a maximum for the horizon or minimum for the nadir and zenith, and that in almost every existing instrument, if not all, the flexure is unequal for the same altitude upon different sides of the vertical. The interchange of object-glass and eye-pieces presupposes either the absence of unsymmetrical parts within the tube, such as the apparatus for illumination and the shafts by which we regulate the amount of light admitted, or the disconnection of these from their gearing or screw-heads. Indeed, nothing like the former can be reasonably demanded,—a sacrifice which seems disproportionate to the end to be attained. Moreover, the new meridian-circle is equipped with more than a usual amount of internal mechanism, although the arrangement and support of this latter has been planned with an especial view to

the avoidance of any prejudical effect arising from unsymmetric distribution of weight. The measurement of flexure may take place without disturbing the adjustments or parts of the instrument, by some apparatus analogous to the neat and practical contrivance of Professor Challis, who arranges a pair of collimators in such a manner that they are used in connection with each other at any desired angle of altitude. Moreover, the reversal of the instrument admits of a scrutiny and check upon the determinations, which provides all needful safeguard against erroneous results.

The circles are divided to 2′, and read by microscope to 0″·1. The unit's place of the degree is always visible within the field of the microscope, and the decades of degrees are engraved upon the rim of the circle. The finders read to 10′, and by vernier to 1′.

The axis is turned within as well as without, a precaution upon which I also insisted with regard to the tube. The cube measures thirteen inches and a half on each side, and the pivots are two inches in diameter. The difficulty of obtaining a satisfactory and suitably homogeneous piece of iron for the axis may be estimated from the circumstance that even in Berlin, justly renowned as is that city for knowledge and skill in everything pertaining to the founding of iron, three successive castings had to be rejected before a satisfactory piece could be obtained; and even then it became necessary to deviate from the original plan, not, however, as I trust, to the disadvantage of the instrument. The weight of the axis is about 350 pounds.

The illumination is entirely by gas, the light designed for the illumination of the field entering by one pivot, and that for the threads by the other. Arrangements are made for illuminating with lights of different colors, and for observing, when occasion requires, with bright threads upon a bright field. The levels are boxed, provided with air-chambers, and read from end to end, not from the middle outwards.

In fine, it has been my endeavor to incorporate in the design of this instrument the principle,—never before attained, so far as I am aware,—that every instrumental correction, without exception, should be capable of determination by two entirely distinct and independent methods; and in this respect also to combine the advantages of the German and the English forms. And I may claim for the new instrument that its errors of graduation, its errors of flexure, collimation, level, azimuth and nadir-point, may all be determined by two separate processes, free from any dependence, direct or indirect, upon each other. And whatever may be its errors of construction or of mounting, there is no fear that they will escape detection and accurate measurement. So

earnest has been my desire to lose none of the advantages on either side of questions upon which experienced astronomers differ in opinion, that no point of detail has been deemed too minute for the application of this idea of duality, and I have even requested the artists to provide one set of microscopes with crosses, after the fashion of Troughton, and the other with close parallel threads, according to the custom of Repsold and the almost universal usage of the German mechanicians.

If this eclectic spirit shall prove to have been successful in attaining its ends without the sacrifice of unity, of artistic or theoretic elegance, of convenience, or of any scientific advantage, the care and labor bestowed upon the decision of the principles which should rule its design will be more than rewarded. But here, as in all instruments of a high order, it is the mechanical artist to whom most of the success is due, and to whose refined delicacy of judgment, taste, and skill we owe the chief advances of modern astronomy. Bessel once said that he could determine the place of a star with a musket-barrel and a cart-wheel. Few things were impossible to Bessel, but you will agree with me that at any rate even a Bessel would with such appliances hardly have determined so large a number of precise star-positions as, thanks to the genius of Fraunhofer, Reichenbach and Repsold, are contained in those noble Königsberg volumes, and are sufficient to render the names of the artist and the astronomer alike immortal.

It is my privilege, on this occasion, to become the organ of the Trustees of the Observatory in announcing that, at the instigation of the Scientific Council, they have given to the new meridian-circle which I have been describing,—which, in the grandeur of its dimensions, is rivaled only by the renowned and gigantic transit-circle of the Royal Observatory at Greenwich, and which, as we are trusting, may prove to be a forward step in instrumental astronomy,—a name which will render the exquisite instrument still more a source of pride to Albany and to the Dudley Observatory,—a name full of associations of disinterested and unassuming liberality, of generous public spirit,—the name of a man who knows no guile, a citizen of large, expanded mind and heart, whose efforts have, under the blessing of a favoring Providence, resulted in an affluence by which all around him are made happy, and without whose constant effort, protecting care, and wise counsel, neither this instrument, nor the Observatory for which it is designed, would ever have existed. The Trustees have authorized me to announce, that, in token of their respect for Thomas W. Olcott, of Albany, the instrument will be known as the OLCOTT Meridian-Circle, and that the name is already engraved upon the telescope at Berlin.

The transit-instrument is similar to the meridian-circle, so far as the latter is an instrument for the measurement of right ascension. It is the property of the Coast Survey of the United States, whose enlightened chief has authorized its employment at the Dudley Observatory for the present. The object-glass has a clear aperture of 72 French lines, and a focal length of 8 feet.

In both these instruments the Ys are so constructed that the level-arm may rest upon that part of the pivot which supports the instrument.

ART. XXXIX.—*On two Sulphurets of Copper from the Canton (Ga.) Mine;* by N. A. PRATT, Jr.

THE discovery in a new mineral locality of two beautifully crystallized sulphurets of copper, identical in composition with copper glance and covelline, the latter of which has never before been found in this country, and indeed in very few localities in the world, is a very interesting fact; but when these minerals are found intimately associated, while at the same time their crystallographic characters differ so widely from the above-mentioned species, and especially as they present a form in which they have never before been observed, they assume a mineralogical importance which demands an investigation of the conditions and manner of their occurrence.

The geological position and character of this mine, as well as the unusual variety of minerals occurring here, have been made the subject of a special and very flattering report by Prof. C. U. Shepard, but so few probably will ever see that report, that a brief outline of the formation will here be given, with only such facts as bear directly on the origin and crystallization of these ores.

The metalliferous rocks are confined to one of many alternations of metamorphic schistose strata, in which hornblendic and mica schists predominate. This 'mica slate' overlying a chloritic slate on the north, and underlying a talcose slate on the south, is itself slightly talcose and at different depths from five to ten feet wide. This whole series trends N. 65° E., and dips to the southeast at an angle varying from 60° to 80°. Whether they are altered beds of the Lower Silurian, such as those of Southeast Tennessee, and known as metamorphic Palæozoic, or belong to the Azoic series, limited investigation has not certainly decided. I think, however, on account of their distance from the Silurian of the State, and the character and uniformly high inclination of the intervening strata, that they will ultimately be found to be-

long to the Azoic. This, however, is by no means certain, and the subject acquires additional interest from the fact that these strata are contemporaneous with the great auriferous belt of the State, and gold is found in the neighboring strata both north and south.

The course of the metalliferous stratum, "the vein," is plainly marked on the surface, by the decomposed ferruginous character of the outcropping rocks. Crystals of staurotide of the thickness of a small needle and from $\frac{1}{8}$th to $\frac{1}{4}$th inch in length, similar to those which so abundantly accompany the ores below though somewhat decomposed, are found imbedded in these rocks, clearly indicating their existence prior to the decomposing action of water on the mineral contents of the vein. At 60 feet, the first traces of copper are found in the form of 'black oxyd,' which evidently contains the sulphuret; and at 96 feet this sulphuret with red oxyd and malachite has materially increased in quantity. These with the abundant existence of the hydrous protoxyd of iron indicate the very general action of oxygen and carbonic acid at this level. The first traces of galena are here found in the tunnel contiguous to the chloritic slate of the north wall; this, as will be seen below, seems to be the normal position of this mineral in the vein. Native copper in small sprigs is also found attached to the very quartzose veinstone.

At 116 feet, near the shaft, all signs of decomposition disappear. The siliceous mica slate, containing segregated masses of pure white quartz, fills the vein. Farther east, iron pyrites in cubes and imperfectly formed octahedrons, forms continuous masses, probably lenticular in shape, six inches to two feet in thickness. They lie nearly parallel to the walls, but are devoid of all signs of stratification. Galena and blende are disseminated through these, filling the interspaces of the crystals of pyrites and apparently acting as a cement to keep them together. In no case have I seen the galena in this connection at all well crystallized but always of a fine granular structure. The ordinary veinstone, a quartzy mica slate, intervenes between these masses, forming two, three, or four alternations according to their own thickness, and the width of the vein. But at 25 or 30 yards from the shaft to the east, the peroxyd of iron shows that at this point the decomposition has extended to greater depths than elsewhere. As the tunnel passes on, the roof presents a series of reddish-brown and white "flucanny" layers, evidently the decomposed continuations of the alternations above mentioned, which with these successive repetitions, taken in connection with the water, which with its salts of copper and iron in solution, is known to have trickled through them, suggests the idea of a huge voltaic pile, the galvano-chemical action of which may

have exerted much influence on their own decomposition and the crystallization of the sulphurets in the immediate vicinity. The relative position of these sulphurets and the rocks with which they lie in contact is important as bearing directly on the formation of the former, as will be noticed in the sequel. The lower limit of decomposition, clearly defined and well marked both by the total disappearance of the peroxyd, and the restoration of the mica schist in its nornal condition, does not descend vertically in the plane of the vein, but takes a downward and easterly course pitching, within the walls of the vein, at an angle of 45°. (In this general direction a winze has been sunk, intersecting the 145 ft. level and communicating with the 200 ft. level below.) Here just at this lower limit of the decomposed area, reminding one, by its position, of the occurrence of the black oxyd, in the famous Ducktown mines, first occur the two sulphurets of copper, which are the subject of this paper. They first appear as a 'string' near but not immediately on the north wall, which while pitching at an angle of 45° to the east, rapidly enlarges to a fine 'bunch' of ore from 14 to 18 inches thick, which now occupies the central part of the metalliferous stratum. The minerals are however generally disseminated in the neighborhood of the 'bunch,' through the body of the vein, which is here 4 or 5 ft. wide, and are co-extensive downward, with the decomposition of the rocks. Solid masses of the ores of 40 and 50 pounds have been taken from the bunch. The latter however contained quartz.

The relative proportion of these minerals (which were at first confounded) varies. The most abundant is identical in its physical properties and composition with copper-glance, while its crystalline structure is that of galena, and on this account it has been made a new species, named 'Harrisite.' It occurs crystallized in considerable masses in contact on one side with the undecomposed veinstone, a quartzy mica slate, and is associated with massive white quartz and staurotide in slender reddish crystals from $\frac{1}{8}$th to $\frac{1}{4}$th inch in length. It also impregnates and gives a dark grey color to masses of granular quartz and staurotide, intimately mixed. Even when crystallized it is sometimes so closely associated with massive erubescite (variegated copper) that the two species cannot be separated. Fine crystals of quartz are found bedding their pyramidal terminations in the mass of the sulphuret. Faces of several quartz crystals sometimes meet at an angle, and the mineral appears wedged in between them, in one case I extracted an almost perfect tetrahedron, the faces formed partly by the crystalline faces of the quartz and partly by the natural cleavage of the ore, which is still eminently monometric.

Intimately associated with this is another new mineral also a sulphuret of copper (CuS) corresponding in its formula with the protoxyd (CuO). A careful analysis of this gave:

Copper 66·205, sulphur 33·490, impurities ·305 = 100.

The impurities consist of silver and staurotide, it being impossible to find a crystal of the sulphuret which does not contain small but perfect crystals of this mineral. Hardness 1·5–2. Specific gravity 4·18, mean of three determinations. Lustre submetallic, shining. Color and streak, blue-black. Thus in physical properties (except streak) and composition it is identical with 'covelline; but while covelline is hexagonal this is monometric and exactly similar to Harrisite and galena. It is also found impalpable. For this mineral I have proposed the name "Cantonite," from the locality. It is found in the greatest quantity and in the largest crystals in contact with much decomposed ferruginous quartz, and in an impalpable state is disseminated through a veinstone of granular quartz and staurotide, in which the latter seems to have replaced the mica of the ordinary veinstone which still retains its imperfectly stratified structure. Iron pyrites, variegated copper and staurotide are frequently bedded in pure Cantonite. It is also found finely crystallized in extremely well formed cubes diffused through large masses of rock made up of small cubic pyrites. It often encrusts the cubes in such a manner as to have the appearance of fine blue cubic Cantonite. Their nature is only discovered by testing their hardness. When we take into consideration the instability of this protosulphuret and its liability to oxydation, thus taking on a soluble form, the comparative scarcity of this mineral in this and other countries is amply accounted for. In fact in this mine, whenever air and moisture find access to strata containing it, the sulphate of copper is formed in fine crystals. I regret that I was unable to examine "in situ" the relative position of these minerals, which no doubt would have thrown much light on the conditions of their formation. They are thus far confined to this portion of the mine.

The galena at this depth is found only in interrupted strings along the foot wall of the vein, and in no case under my observation is it in contact with the sulphurets or in their immediate vicinity. Small sprigs of native copper are here implanted on the galena, and fine crystals of zinc spinel (automolite) occur. In the tunnels below this, at 145 and 200 ft., the veinstone remains fresh and undecomposed, containing copper pyrites, disseminated through its mass. Large cubes of pyrites, crystals of mispickel, copper pyrites and automolite, line and often fill crevices in the veinstone. Pure galena in small bunches is scattered through the slate, and the pyritiferous masses still alternate with

the hard quartz slate. Galena still fills strings on the north wall, and it is remarkable that in this position the specimens exhibit a rather large cubical fracture, while in most and the largest bunches in the body of the vein, they show a compact granular structure. The percentage of silver in the galena of any mine varies with the position of the lead ore, and my examination shows that in this view it increases with its approach to the north wall. In different determinations I have found from 0·1 to 0·3 per cent, equal to 32 and 96 oz. per ton of ore. Kyanite is found in flat crystals facing crystals of galena. Carbon in the form of graphite occurs as a fine black coating on seams of galena.

The fresh undecomposed mica slate impregnated with copper pyrites, with its bands or plates of cubical pyrites, exhibited in the lower levels may, I think, be taken as representing the condition and appearance of the rocks above, previous to their decomposition. The sulphate of copper, formed during the oxydation of the copper pyrites, when taken in solution by the water percolating the mass, would be in a condition to assist in the formation of other compounds of copper, while the hydrous peroxyd of iron, formed during the same decomposition, would be left staining the strata from which the copper has been extracted. That the Harrisite and Cantonite were formed from the sulphate of copper in solution, is evident from their position at the lower limit of decomposition and the fact that they are found under no other conditions in the mine. As to the chemical agencies by which black oxyd, native copper, and these sulphurets have been precipitated, perhaps from the same solution—we have no positive evidence. In one case, at least, that of native copper, electro-chemical forces have no doubt been in operation. As regards the sulphurets—since graphite is found coating seams of galena the carbon of which was derived from organic matter in solution, analogy would look to the *possibility* of their formation by the reciprocal action of organic matter and the salt of copper, just as actual experiment has shown crystals of pyrites to be formed. And if future examination should prove that these are altered silurian strata, organic matter has not been wanting for all purposes of deoxydation.

But in galvano-chemical action we have, I think, an explanation of all the phenomena presented in the peculiar occurrence of the ores of copper in this mine; and I propose to embody in another paper, a series of experiments, showing, in this and other mines, the successive changes from copper pyrites, through variegated copper and copper glance to native copper and black oxyd. By the investigations of Mr. Robert Weir Fox and Mr. Robert Hunt on the Cornish veins, the fact was established, that in certain metalliferous veins, local galvano-electric currents existed, capable of producing chemical decomposition.

And in 1836, Mr. Fox submitted to the British Association an experiment showing that yellow copper (pyrites), in a dilute solution of sulphate of copper, under the influence of a weak galvanic current, undergoes a change by which "a black and somewhat friable crust" of sulphuret of copper was formed, and native copper deposited in "brilliant crystals" on the sulphuret.

That all the conditions for such decomposition and recomposition occur at the Canton mine, the above description will amply testify, and that such changes are in actual progress is proved by a specimen of copper pyrites in my possession, which is completely blackened by a very thin coat of the sulphuret, while mispickel and pyrites in immediate contact still retain their color and lustre. This power thus exerted in the formation of Harrisite and Cantonite is probably as active in pseudomorphic changes as in any other. The question then arises, Can they be pseudomorphs? On my first examination of these crystals in August, 1855, I considered them copper-glance in forms of galena, and their porosity, well exhibited in taking their specific gravity by the escape of air bubbles, strengthened that opinion. Subsequent examination of the locality and a greater variety of specimens, has entirely removed that impression. The occurrence of both minerals crystallized in connexion with erubescite renders it highly improbable that they replaced galena in that connection. Galena, with a cubical fracture (if it does in any form) does not occur in contact with the sulphurets. Nor are *they* found occupying the normal position of the galena, in strings along the wall.

This negative evidence, with some minor considerations, but especially the character of the crystals, the lustrous cleavage planes of which, with their sharp and well-defined angles, disagreeing so decidedly with pseudomorphic characters, renders some *positive* evidence necessary to prove them pseudomorphs.

Nor can Cantonite be Covelline in form of Harrisite, since the latter is never found among cubic pyrites, where the former is so beautifully crystallized. There is at least an improbability also that the easily decomposed protosulphuret could replace the very stable disulphuret.

In conclusion, I infer from the results of this investigation that copper glance is dimorphous, Harrisite being its monometric form. Also that Covelline is dimorphous, Cantonite being its monometric form. The cause of this latter dimorphism will probably be found in the fact that the monometric crystals are formed by aqueous, and the hexagonal (covelline) by igneous agency. Again, that Harrisite and Cantonite will not be found at great depths, but only within the range of decomposition. On the copper pyrites, then, and the argentiferous galena, will depend the value of this mine.

ART. XL.—*Contributions to Mineralogy;* by Dr. FREDERICK A. GENTH.

SINCE my last contribution to Mineralogy, (Am. Journ. of Sci., xix, 15,) I have examined a number of minerals, the constitution of which appeared not to be satisfactorily settled, and in the following pages, give the results of my examinations.

1. *Bismuthine from Riddarhyttan in Sweden.*

The frequent occurrence of tellurium in minerals containing bismuth and the probability that both metals can replace each other, induced me to examine a specimen from Riddarhyttan. The bismuthine is implanted in actinolite, the crystals of which often penetrate it, and is associated with chalcopyrite and allanite (cerine), and by its broadly foliated structure and perfect cleavage somewhat resembles the tetradymite from Fluvanna county, Va. It was found to contain:

Sulphur,	18·19 p. c.
Tellurium with a trace of Selenium,	0·30 "
Bismuth,	77·33 "
Copper,	0·39 "
Iron,	0·31 "
Actinolite,	2·93 "
	99·45

After deducting the actinolite and 1·12 p. c. of chalcopyrite, the percentage of the pure mineral would be:

Sulphur,	18·65 p. c.
Tellurium,	0 32 "
Bismuth,	81·03 "
	100 00

From this analysis it appears, that the general formula for bismuthine should be written (Bi, Te)S_3.

2. *Harrisite* (Shepard), *a pseudomorph of Copper-glance after Galena.*

Prof. C. U. Shepard describes in his Report on the Canton Mine, (Savannah, 1855, and 2d edition, New Haven, 1856), under the name Harrisite, as a *new species* an interesting pseudomorph of copper-glance after galena.

Early in this year I examined the Canton mine and collected part of the material and data for the following investigation. I am also indebted to Dr. W. C. Daniell, Prof. Julien M. Deby and W. F. Harris, Esq., for minerals from this mine.

At the 115 foot east level of the Canton mine, the Harrisite* was found in a vein-like pocket, which dipped at an angle of about 30° towards the east, in the ore stratum, and extended as

* I may be permitted for the sake of convenience to use in this paper the names Harrisite, Cantonite, etc., for copperglance after galena, covelline after galena, etc.

far as the 141 foot level, where it gradually disappeared. At its widest place it was two feet in thickness and consisted of a very friable quartz with mica, supposed staurotide or partschine (Shepard) (?), automolite, Harrisite, Cantonite, pyrites, etc. At the 141 foot level the quartz becomes so much mixed up with pyrites, galena, chalcopyrite, etc., that it loses its vein-like character and has united with the wedge-shaped metalliferous mass in the ore stratum, where its presence can be recognized by the automolite and supposed staurotide or partschine. No Harrisite has ever been observed below 141 feet depth, and it has given place to the unaltered galena. It may be found again however, if the ore-stratum of the Canton mine or a similar one should be developed where the atmospheric influences have been favorable to such changes.

Harrisite has very much the appearance of a dark variety of galena, though it is always darker than the darkest, which I have ever seen. It occurs both in broadly foliated and granular masses, which show a perfect cleavage even to the smallest fragments. Between the cleavage planes, which are often tarnished, we frequently find a coating of clay.

It has lost its compactness and has become friable. Sp. Gr. (at 20° Cels.) = 5·485. H. = 3—3·5.

The material for the analyses was treated with chlorhydric acid, washed and dried over sulphuric acid, in order to obtain it in a state of perfect purity. I found:

	I.	II.
Sulphur,	20·648	20·647 p.c.
Selenium,	not determined.	0·047 "
Silver,	0·207	0·164 "
Copper,	77·298*	77·758 "
Lead,	0·056	0·060 "
Iron,	0·442	0·359 "
Insoluble,	0·272	0·667 "
	98·923	99·702

The eminent cleavage of this pseudomorph in the form of the original mineral has for a long time perplexed and kept me in doubt, whether it might not be a good species after all, but the more carefully I have examined the specimens in my possession and those at the Canton mine, the more have I become convinced that it is a pseudomorph.

Though we do not very often meet with pseudomorphs retaining the cleavage of the original mineral, yet several such cases have been observed, and they occur very naturally with those species of minerals that have an eminent cleavage. This caused them to change from a single one to an aggregate of innumerable individuals, by agencies, such as heat, pressure, etc., which would not have affected them, if the particles had been less easily sepa-

* Some was accidentally lost.

rable from each other. Before their conversion into the new mineral we have to consider such masses not as *one* individual, but as made up by the close juxtaposition of a great number of single individuals, each of which had been altered separately from the others, and which after their alteration had not the power to unite again into a single one.

A very remarkable pseudomorph of this kind is that of gypsum after anhydrite with perfect anhydrite cleavage from Pesey in Savoy; others are calcite after gypsum with the cleavage of the latter, and minium after galena with cubical cleavage; but the most interesting is a pseudomorph after Harrisite, which I shall describe presently, and which has been named Cantonite. Another proof that Harrisite is a pseudomorph after galena and Cantonite one after Harrisite, is their yield of silver, which is corresponding with that of the unaltered mineral. The galena contains from 0·10 to 0·18 p. c. of silver, the Harrisite from 0·16 to 0·20, and the Cantonite, as we shall see by comparing the analyses of it, from 0·30 to 0·35 p. c., which is nearly in the inverse ratio of the equivalents of galena, copper-glance and covelline. The presence of selenium, which I have also observed in the galena, is further to be remarked, both in the Harrisite and Cantonite.

Breithaupt, in his Paragenesis, p. 185, mentions copper-glance after galena as having been found in Saxony.

We may readily conceive how the Harrisite has been formed, if we bear in mind an observation of Anthon, that freshly precipitated sulphid of lead, throws down sulphid of copper, when added to solutions of coppersalts, and that I have found that galena precipitated sulphid of copper from the nitrate, though this reaction was gradual.

Whether Scheerer's copper-glance from Tellemark, Norway, with cubical cleavage is a similar pseudomorph or a distinct species, I am not prepared to say, but from the experiments of Mitscherlich and G. and H. Rose, that by fusion of sulphur and copper or copper-glance, a monometric subsulphid of copper can be obtained, it is not improbable that under favorable circumstances it may also be found in nature.

3. *Cantonite* (Pratt), *a pseudomorph of Covelline after Galena.*

Mr. N. A. Pratt announces (Am. Jour. Sci., xxii, 449) as a new species, which he calls Cantonite, a very rare and interesting pseudomorph of covelline after galena, or rather after Harrisite, the latter having been the intermediate result of the decomposition. He promises in his announcement to give in the next number of the Am. Jour. of Sci. a full description of it, but having failed to do so in the numbers for January and March 1857, I do not hesitate to give the results of my investigations.

It occurs associated with Harrisite, etc., in crystalline masses with perfect cubical cleavage. The color is dark indigo-blue, the lustre between submetallic and resinous. Its powder is bluish-black, when rubbed in the agate mortar, indigo-blue and shining. It is soft, very friable and somewhat sectile.

Sometimes it contains a nucleus of Harrisite (analysis II). It should be remarked that the angles of pyrites associated with the Cantonite have frequently rounded edges, and that black oxyd of copper often occurs with it. To free it from the latter the material for analysis was first digested with diluted chlorhydric acid. It contains:

	I.	II. (containing Harrisite.)	
Sulphur,	32·765	28·664 p. c.	
Selenium,	*trace*	*trace*	
Silver,	0·355	0·305 "	
Copper,	65·604	70·791 "	(from the loss.)
Lead,	0·107	0·025 "	
Iron,	0·251	0·084 "	
Insoluble,	0·157	0·131 "	
	99·239	100·000	

4. *Linnæite.*

a. Carrollite (Copper-linnæite) from the Patapsco Mine.

Although the constitution of this interesting mineral has been satisfactorily established by Smith and Brush (Am. Jour. Sci., xvi, 367), I considered a re-examination not to be out of place on account of the difficulty of obtaining pure material, such as is entirely free from chalcopyrite, copper-glance, etc. After having observed that carrollite is very little acted upon by nitric acid, I have endeavored to purify some of it, by digesting the mixture of chalcopyrite and carrollite with diluted nitric acid. I was disappointed in my expectations, finding that in the presence of chalcopyrite, the carrollite was far more readily dissolved, whilst the former appeared to be more protected. After having abandoned the idea of getting pure material by the help of chemicals, I was fortunate enough to obtain a perfectly pure specimen, weighing about four grammes.

The color was between steel-grey and tin-white, with a very faint reddish hue. It was not crystallized, and like all the carrollite which I have seen, did not show the least indication of cleavage, but a subconchoidal fracture.

Dissolves slowly in nitric acid *without* separation of sulphur. The results of the analysis agree with those of Smith and Brush.

Sulphur,	41·71 p. c.
Copper,	17·55 "
Nickel,	1·70 "
Cobalt,	38·70 "
Iron,	0·46 "
Quartz,	0·07 "
	100·19

I may state that I have also observed this mineral at the Springfield Mine, Carroll County, Md., from which locality I have an octahedral crystal.

In Prof. J. D. Dana's Mineralogy the formula is written

$$CuS + Co^2S^4 \text{ instead of } CuS + Co^2S^3.$$

b. Siegenite (Nickel-linnœite) from Mineral Hill, Md.

A mineral, which has sometimes been confounded with Carrollite, occurs at the Mineral Hill Mine, Carroll County, Md., about eight miles from Finksburg.

It is found in a vein in chlorite slate and is associated with chalcopyrite, erubescite, blende, pyrites, magnetite, actinolite and quartz. It is so intimately mixed with chalcopyrite that I found it impossible to pick out enough of pure material for a single analysis, though I had used several pounds of the mineral. The only impurity, as can be seen by examining it with a magnifier, being chalcopyrite, it is easy to correct the analyses by deducting it from the same.

The color is pale steel-grey, with a distinct yellowish hue, undoubtedly owing to an admixture of chalcopyrite; its cleavage is distinctly cubical.

Dissolves slowly in nitric acid, but more readily than Carrollite, without separation of sulphur.

The following results were obtained by the analyses of two different specimens:

	I.	II.	
Sulphur,	39·70*	41·15 p. c.	
Copper,	2·23	3·63 "	
Iron,	1·96	3·20 "	
Nickel,	29·56	} 50·76 "	(from the loss.)
Cobalt,	25·69		
Insoluble,	0·45	1·26 "	
	99·59	100·00	

The nickel and cobalt in analysis II. were in about the same proportion as in I.

Both the copper and iron result from the presence of chalcopyrite. That the pure siegenite from this locality does not contain any iron can be seen by calculating from and for the percentage of copper obtained, the quantity of iron requisite to form chalcopyrite. In analysis I. 2·23 p. c. of copper require 1·94 p. c. of iron and 2·25 p. c. of sulphur to form chalcopyrite, of which the mineral analyzed therefore contained 6·42 p. c.; in analysis II. 3·63 p. c. of copper require 3·20 p. c. of iron and 3·66 p. c. of sulphur, showing that the siegenite analyzed contained 10·49 p. c. of chalcopyrite.

c. Siegenite (Nickel-linnœite) from Mine La Motte, Missouri.

The cobalt and nickel-ore from Missouri has been used for a number of years for the manufacture of oxyd of cobalt and

* Some was accidently lost.

nickel, but I am not aware that a scientific examination of the pure mineral has ever been made. This may be owing to the difficulty in obtaining pure material, as it is always mixed with galena, chalcopyrite, marcasite, etc. I have endeavored to pick it out as pure as possible, and have pretty well succeeded in removing the greater portion of the remaining galena by previously treating it with strong and boiling chlorhydric acid.

The siegenite from this locality is rarely found in crystals; those which I have observed were both octahedra and cubo-octahedra. Its cleavage is very indistinct; the color between steel-grey and tin-white. It dissolves in nitric acid without separation of sulphur. The analysis gave the following results:

Sulphur,	41·54 p. c.
Lead,	0·39 "
Nickel,	30·53 "
Cobalt,	21·34 "
Iron,	3·37 "
Insoluble,	1·07 "
	98·24

with traces of copper and antimony.

5. *Enargite* (?)

In small cavities of a hornstone-like quartz at the Brewer's Mine, Chesterfield District, S. C., occurs very rarely an iron-black mineral with metallic lustre and perfect rhombic cleavage. I am indebted to the State Geologist of South Carolina, Oscar M. Lieber, Esq., its discoverer, for a small specimen of it.

Mr. Lieber in a qualitative examination found it to contain sulphur, arsenic and copper.

Before the blowpipe it decrepitates, on charcoal with soda gives hepar, the odor of arsenic and finally copper. Though the quantity placed at my disposal was entirely too small for a complete examination, I thought that I might be able at least to ascertain to what species it belongs. The following are my results: 0·0060 grs. gave 0·0149 grs. sulphate of baryta; 0·0040 grs. of oxyd of copper and 0·0005 grs. of magnesia, which is equivalent to 0·00094 grs. of arsenic. The percentage calculated from these results is:

Sulphur,	33·78
Arsenic,	15·63
Copper,	50·59
	100·00

Until larger quantities can be obtained, which permit of a more complete investigation, I think I am justifiable in calling this mineral Enargite.

6. *Coracite* (LeConte) *is Pitchblende.*

Dr. John L. LeConte kindly presented me with a specimen of the mineral from about 90 miles above Sault St. Marie on the north side of Lake Superior, which he had described as Coracite (Am. Journ. Sci. iii, 173).

Its great resemblance to pitchblende favored the opinion that it was really nothing else. Mr. Whitney (Bost. Soc. Nat. Hist., 1849, 36), suggested that the Uranium might be in the form of U_2O_3 and not of UO, U_2O_3, but stated, that it yields a green solution with chlorhydric acid.

I endeavored to extract the carbonate of lime, which is mechanically mixed with it, by very dilute acetic acid, but I soon observed that the coracite was also acted upon and that the liquid became green; I therefore washed it completely, dried over sulphuric acid and used the partly extracted substance, which was slightly acted upon by the acetic acid, for analysis.

Before giving the results, I will state that the protoxyd of uranium was determined by dissolving the mineral in a mixture of chlorhydric acid and chloraurate of sodium and by calculation from the quantity of reduced gold. The separations were made as usual with exception of that of uranium from iron. By qualitative experiments I ascertained that this separation could be made more easily and accurately by the precipitation of the sesquioxyds of iron and uranium by ammonia from a boiling solution and re-solution of the sesquioxyd of uranium by digestion with dilute acetic acid.

I obtained the following results:

Sesquioxyd of uranium,	46·21	contains 7·76 oxygen.
Protoxyd of uranium,	16·47	" 1·95 "
Sesquioxyd of iron,	3·51	p. c.
Alumina,	0·52	"
Magnesia,	0·56	"
Lime,	5·33	"
Oxyd of lead,	7·39	"
Silicic acid,	13·15	"
Carbonic acid and water,	6·14	"
	99·28	

The ratio of oxygen in UO to U_2O_3 is very near $=1:4$. The excess of uranic oxyd may be accounted for by partial oxydation or perhaps by the presence of a combination of it with oxyd of lead, and though it is interesting that it is so readily soluble in chlorhydric acid, this fact alone is not sufficient to separate it from pitchblende.

7. *Epistilbite.*

Mr. C. A. Kurlbaum, Jr., has examined in my laboratory the epistilbite from Iceland with the following results:

Silicic acid,	58·74 p. c.
Alumina,	17·10 "
Sesquioxyd of iron,	0·12 "
Lime,	7·81 "
Soda,	2·06 "
Potash,	0·19 "
Water,	14·21 "
	100·23

8. *Shepard's Plumbo-Resinite from the Canton Mine is Cyanosite.*

I am indebted to W. F. Harris, Esq., who had the advantage of Prof. C. U. Shepard's *own* mineralogical determinations for a genuine specimen of what the latter in his report on the Canton Mine calls Plumbo-Resinite. It forms as Prof. Shepard remarks, "*varnish-like coatings of a yellowish green color.*"

With great care I have separated some of the mineral from the quartz with which it occurs and examined it.

Before the blowpipe on heating loses water and becomes greyish-white; on being exposed to a higher temperature on charcoal it yields a black mass containing metallic copper; with carbonate of soda upon charcoal gives a hepar and metallic copper. Dissolves easily in water; the solution has a very astringent metallic taste, and contains oxyd of copper and sulphuric acid. It does not contain either alumina or oxyd of lead, and with a solution containing nitric acid only a very slight yellowish color could be produced by molybdate of ammonia.

9. *Cherokine* (Shepard) *is Pyromorphite.*

By the kindness of F. W. Harris, Esq., I have received a genuine specimen of Prof. Shepard's Cherokine. As he stated in his report on the Canton Mine, "*it resembles white lead ore (carbonate of lead) in its color, but possesses the crystalline form of pyromorphite, while it contains phosphate of alumina and oxyd of zinc and further differs from Plumbo-Resinite by containing much less water,*" etc. Some qualitative tests which I have made with a crystal of the mineral gave me very different results, and I have not been able to distinguish it from pyromorphite. A special search was made for water, alumina and oxyd of zinc, but neither were found. Before the blowpipe also it behaves like pyromorphite and melts easily, the globule assuming on cooling a polyhedral form.

10. *Vivianite.*

Mr. C. A. Kurlbaum, Jr., (analyses I and II) and I (III) have examined a massive indigo-blue variety of vivianite from Allentown, Monmouth county, N. J.

	I.	II.	III.
Phosphoric acid,	29·65	29·21	29·48
Protoxyd of iron,	27·62	not determined.	
Sesquioxyd of iron,	18·45	not determined.	49·70
Magnesia,	0·03	0·10	not determined.
Water,	25·60	not determined.	
	101·35		

The analyses afford the formula :

$$10(3FeO, PO_5+8HO)+3(3Fe_2O_3, 2PO_5+10HO)$$

11. *Wavellite.*

About one mile from the Railroad Depot at Steamboat, Chester county, Pa., wavellite has been discovered in great abundance and in beautiful varieties. By the kindness of Dr. Hartman of West Chester, I have received several specimens, which have furnished me with the material of investigation.

It is found in minute rhombic, sometimes stellated crystals, which, according to Prof. J. D. Dana's measurement have a prism of 123°—124°. Usually however they form stalactitic or botryoidal concretions coating limonite. The wavellite is often coated with a micaceous mineral, which I have not obtained in sufficient quantity to ascertain its composition.

After having found by some qualitative experiments that phosphoric acid could be *completely* separated from alumina by dissolving in an excess of caustic potash, and precipitation of the phosphoric acid by caustic baryta, I have analyzed this wavellite by this method, and satisfied myself afterwards that the separation had been complete.

I must add, however, that I have not always succeeded with this method, but as yet do not know the reason.

The stalactitic wavellite from this locality contains :

Phosphoric acid,	34·68 p. c.	contains oxygen	19·44
Alumina,	36·67	"	"	17·14
Limonite,	0·22			
Water,	28·29	"	"	25·14
Fluorine,	*trace*			
	99·86			

The oxygen ratio of $PO_5 : Al_2O_3 : HO$ corresponds with the atomic ratio, 3·9 : 5·7 : 25, which very nearly gives the formula $3Al_2O_3, 2PO_5+12HO$, as Sonnenschein has already observed.

12. *Dufrenite.*

This mineral occurs in the green sand formation at Allentown, N. J., in radiated fibrous masses, forming a coating of one-eighth to half an inch in thickness. Its color is dark leek green, in some places, where it is beginning to change into limonite, it is brown. The powder has a dull greyish green color.

Mr. Chas. A. Kurlbaum, Jr. has examined the green mineral, which was apparently quite pure and obtained the following result:

Silicic acid,	0·72	p. c.		
Phosphoric acid,	32·61	"	contains oxygen	18·28
Protoxyd of iron,	3·77	"	"	0·84
Sesquioxyd of iron,	53·74	"	"	16·10
Water,	10·49	"	"	9·32
	100·95			

From the oxygen ratio of $PO_5 : FeO : Fe_2O_3 : HO$, we find that the atomic ratio is 3·65 : 0·84 : 5·87 : 9·3, which is equal to 13 : 3 : 19 : 33, or very nearly gives the formula:

$$(3FeO, PO_5+8HO)+6(3Fe_2O_3, 2PO_5+4HO).$$

It appears that the mineral analyzed contained some vivianite mixed with it, and that the formula of the pure dufrenite would be $3Fe_2O_3, 2PO_5+4HO$.

The calculated percentage corresponding with this formula is:

Phosphoric acid,	34·10
Sesquioxyd of iron,	57·31
Water,	8·59
	100·00

It is remarkable that the amount of sesquioxyd of iron, calculating all the iron as sesquioxyd, would be 57·51 p. c. It is not improbable that this dufrenite is in the state of alteration into vivianite.

13. *Hitchcockite* (Shepard).

Hitchcockite, according to Prof. C. U. Shepard's statement (Report on the Canton Mine), is a "*white earthy shell, sometimes no thicker than a mere varnish,—a hydrated phosphate of alumina with oxyd of zinc*," and is enumerated by him amongst the "*ores of zinc.*"

On my late visit to the Canton Mine I procured a considerable number of specimens of this interesting *new* mineral, and the following are the results of my examinations.

With a good magnifier only it can be observed that this mineral has a crystalline structure. It usually occurs in botryoidal concretions or small mamillary incrustations. Color white, yellowish, bluish and reddish-white; powder white. Lustre subresinous, subvitreous and dull. Translucent.

It has an argillaceous odor when breathed upon. Brittle; fracture uneven. H.=4·5. Sp. Gr. (at 20° Cels.) about 4·014.

Before the blowpipe shrinks but does not fuse; with cobalt solution gives a fine azure blue mass; with carbonate of soda on charcoal yields metallic lead and lead incrustations. Dissolves both in boiling nitric and chlorhydric acids, more readily in the latter. The following are the results of my analyses:

	I.	II.			
Insoluble,	1·11	0·48	p. c.		
Chlorine,	not determined.	0·04	"		
Carbonic acid,	not determined.	1·98	"	contains oxygen	1·44
Phosphoric acid,	18·74	18·74	"	" "	10·50
Oxyd of lead,	not determined.	29·04	"	" "	2·11
Alumina,	24·69	25·54	"	" "	11·91
Sesquioxyd of iron,	0·68	0·90	"	" "	0·27
Lime,	1·49	1·44	"	" "	0·69
Water,	21·65	20·86	"	" "	10·55
		99·02			

Deducting 0·72 of oxygen of bases RO for the quantity of carbonic acid found, and considering the carbonate as an impurity, the oxygen ratio of $PbO : Al_2O_3(Fe_2O_3) : PO_5 : HO$ is equal to $2·08 : 12·18 : 10·50 : 18·55$ or equal to the atomic ratio of $2 : 4 : 2 : 18$ corresponding with the formula

$$3PbO, PO_5+3Al_2O_3, 2PO_5+3(Al_2O_3, HO)+24HO.$$

The calculated percentage of the pure mineral is therefore:

$3PbO$,	334·8	30·44 p. c.
$6Al_2O_3$,	308·0	28·01 "
$3PO_5$,	214·0	19·46 "
$27HO$,	243·0	22·09 "
	1099·8	100·00

14. *Lanthanite.*

To Dr. Montroville M. Dickeson, the discoverer of the beautiful and extremely rare lanthanite from near Bethlehem, Pa., I am indebted for a small specimen of this interesting mineral. I have to add only a few remarks to the investigations of Mr. Wm. P. Blake (Amer. Jour. Sci., xvi, 228) and Prof. James L. Smith (ibid., xviii, 378, 427), as the results of my analyses agree with those of Blake and Smith. Sp. gr. (at 20° Cels.) = 2·605.

In analysis I, the crystals of lanthanite were carefully selected and appeared to be quite pure; in analysis II, the mixture of lanthanite, quartz, and an ochreous substance were treated with very dilute acetic acid, and the percentage given below is that of the soluble portion only, which did not contain anything else than lanthana and oxyd of didymium.

	I.	II.
Lanthana (with oxyd of didymium),	54·95	54·83
Carbonic acid,	21·08	——
Water (from the loss),	23·97	——
	100·00	

On boiling with water, the crystals of lanthanite are decomposed into a white powder, which is probably a basic carbonate. The quantity of material at my disposal was not sufficient to ascertain the composition of it. It is not improbable, however,

that the Bastnaes mineral is the same substance and Hisinger's formula consequently correct.

I hope to be able hereafter to settle the doubts which exist on this point.

Prof. C. U. Shepard states (Report on the Canton Mine) that he has observed this mineral at the Canton Mine, he does not inform us, however, what induces him to take the pink-colored crystals for lanthanite. I have not been able to procure a specimen of it and also did not succeed in finding any indications of minerals containing cerium or lanthana, from the decomposition of which the lanthanite could have been formed.

15. *Bismuthite.*

I have made an examination of the bismuthite from the Brewer's Mine, Chesterfield District, S. C., with results not materially differing from those obtained by Prof. Rammelsberg (Pogg. Ann., lxxvi, 564). The material for examination was kindly furnished by Dr. Asbury of Charlotte, N. C., Prof. Lewis R. Gibbes of Charleston, S. C., and Oscar M. Lieber, Esq. of Columbia, S. C. The appearance of the specimens did not differ much except in the richness of the pieces, some of them containing a very large percentage of the brown ochreous residue, insoluble in dilute nitric acid.

I have analyzed a pale variety (I) and a darker one (II), and made two analyses of each, one by treating the finely powdered mineral with dilute nitric acid (*a*), the other by digestion with strong chlorhydric acid (*b*), by which everything, except the silicic acid, is dissolved.

The quantities of lime and magnesia were found to be very small and have not been determined.

The following are the results:

	I.		II.	
	a	*b*	*a*	*b*
Insoluble in dil. NO_3, containing water,	25·42 (1·59)	—	28·16 (2·62)	—
Teroxyd of bismuth,	64·72	64·24	62·15	61·45
Tellurous acid,	—	0·05	—	0·06
Sesquioxyd of iron,	0·91	6·64	1·30	11·20
Alumina,	0·74	1·18	0·68	2·09
Silicic acid,	0·48	17·78	—	13·99
Carbonic acid,	—	5·08	—	5·12
Water,	—	3·94	—	5·41
		98·91		99·32

Deducting the amount of water, which the residue insoluble in nitric acid contains, from the whole quantity given in the analyses (*b*) we obtain pretty correctly (though somewhat too high) the amount of water combined in the pure bismuthite. We would have therefore:

	I. (b)				II. (b)			
Teroxyd of bismuth,	64·24	contains	6·65	oxygen,	61·45,	contains	6·36	oxygen.
Carbonic acid,	5·05	"	3·67	"	5·12	"	3·72	"
Water,	2·35	"	2·09	"	2·79	"	2·48	"

The atomic ratio of $BiO_3 : CO_2 : HO$ is therefore:

in analysis I, 2·22 : 1·83 : 2·35
in analysis II, 2·12 : 1·86 : 2·48

The first analysis corresponds nearly with the formula:

$$9(BiO_3, CO_2)+2(BiO_3, HO)+10HO,$$

the second with:

$$6(BiO_3, CO_2) + BiO_3, HO + 7HO.$$

These analyses, like the one made by Prof. Rammelsberg, prove, (and that is all, I think, which can be expected from the examination of so impure a mineral,) that the Bismuthite from Chesterfield District is a basic carbonate of bismuth with water.

A new locality of bismuthite is in Gaston county, N. C., where it has been discovered by Dr. Asbury of Charlotte, N. C., to whom I am indebted for specimens of it. It occurs there associated with native gold in yellowish-white concretions, which are usually pulverulent, but sometimes show a crystalline structure.

In the matrass it yields water, becoming yellow, and on higher heating fuses easily into a brown mass, which assumes a straw-yellow color on cooling. Upon charcoal it is easily reduced into metallic bismuth, whilst the charcoal is covered with yellow incrustations, having a white margin; for a moment the characteristic bluish green flame of tellurium may be observed.

Dissolves easily in chlorhydric and nitric acids with effervescence of carbonic acid. The solution gives the reactions of teroxyd of bismuth.

I hope to be able to procure more of it in order to make a complete examination which will be of interest, as the material can be obtained in the state of great purity and would assist in settling the doubts still remaining as to the composition of bismuthite.

Philadelphia, March 14, 1857.

Art. XLI.—*On the Separation of Lithia and Magnesia;* by J. W. Mallet, Ph.D.

In the description of methods for the separation of magnesia from the fixed alkalies we find in the standard works on analytical chemistry but few observations referring specially to lithia; and yet the close analogy existing between the compounds of this alkali and those of magnesia would seem likely to render the separation more difficult than in the case of potash or soda.

The opinion has indeed been expressed by L. Troost,* who has lately made some experiments upon the salts of lithia in the laboratory of M. Sainte-Claire Deville, that the two bases in question are so closely analogous, that the only means of separating them is by the employment of caustic potash, which precipitates magnesia alone.

I have felt anxious to examine the grounds upon which this opinion rests, and in particular to ascertain whether lime or baryta may not be used with as good result as caustic potash, since I had depended upon the former of these earths for the purification from magnesia of the salt which I used in determining the atomic weight of lithium.†

I first examined the chlorid of lithium which had been prepared for the experiments on atomic weight, and found that caustic potash did not indicate the presence of a trace of chlorid of magnesium.

This chlorid of lithium then, and the sulphate of lithia prepared from it, might be looked upon as pure salts of the alkali, and safely used in the subsequent analytical experiments.

Among the methods in use for the separation of magnesia from potash and soda, but three appeared worthy of investigation with reference to lithia; the employment of oxyd of mercury as recommended by Berzelius, precipitation with baryta water, and precipitation with milk of lime. Ignition of the mixture of magnesia and the alkalies with carbonate of ammonia does not succeed well with lithia, as H. Rose remarks,‡ since the carbonate of lithia formed is with difficulty and imperfectly extracted by water.

In order to test the applicability of Berzelius's method, the use of HgO, the following mixtures were prepared. No. 1, ·5392 grm. of anhydrous LiCl was dissolved in a little water and added to ·0909 grm. of MgO dissolved in muriatic acid. No 2, ·5942 grm. of LiCl and ·2198 grm. of MgO.

To each of the solutions an excess of oxyd of mercury in very fine powder was added, and they were then gently evaporated to dryness in porcelain crucibles, and ignited until the whole of the mercury was driven off. Water was added to the contents of the crucibles after cooling. They were allowed to digest for some time, and the magnesia which had been formed was filtered, thoroughly washed, ignited, and weighed. The filtrate was evaporated to dryness with the addition of a slight excess of sulphuric acid, and the sulphate of lithia was ignited and weighed.

The mixture No. 1 yielded ·6067 grm. of LiO, SO_3 and ·2387 grm. of MgO. No 2 gave ·7108 grm. of LiO, SO_3 and ·3414 grm. of MgO. Reducing to LiO by calculation, and expressing the results for 100 parts, we have—

* Comptes Rendus, Nov. 10, 1856.—Republished in Chemical Gazette, Dec. 15, 1856. † This Journal, Nov. 1856. ‡ Handb. d. Anal. Chemie., B. 2, S. 45

	Actually Contained.		Found.	
	No. 1.	No. 2.	No. 1.	No. 2.
LiO - - - -	67·67	48·83	58·84	45·13
MgO - - -	32·33	51·17	84·95	79·48
	100·00	100·00	143·79	124·61

The gross inaccuracy of the above results proved on examination to arise from the action of oxyd of mercury upon chlorid of lithium, removing from it, as from chlorid of magnesium, chlorine, which was replaced by oxygen; so that a large amount of caustic lithia was found. The caustic alkali had acted energetically upon the porcelain crucibles, and both in the matter insoluble in water, which had been weighed as magnesia, and in the filtrate from this, silica, alumina, etc., were easily detected. The corrosion of the crucible went further, it will be seen, in the case of Mixture No. 1, in which a larger proportion of chlorid of lithium occurred, than in No. 2. There is a considerable loss of lithia in both cases, although the sulphate as weighed contained a little silica, &c.; this is owing in part to the retention of lithia in a state insoluble in water (but separable by muriatic acid) with the magnesia, silica, and alumina; and in part perhaps to a little of the chlorid having been volatilized as such.

To obtain some idea of the facility with which chlorid of lithium might be converted into lithia by means of oxyd of mercury, I made a separate experiment upon 1·2778 grm. of the pure salt. This quantity was dissolved in a little water, evaporated to dryness with 5 grm. of finely pulverized HgO, and ignited until the mercury was completely driven off. The residue in the crucible was dissolved in water with a little nitric acid, filtered, and chlorine precipitated from the filtrate by nitrate of silver, 3·3489 grm. of chlorid of silver were obtained = ·8279 grm. of chlorine, or 64·79 p. c. of the LiCl employed;—83·53 p. c. is the proportion in the pure salt, so that about one-fourth of the chlorine had been replaced by oxygen.

The effect of ignition with oxyd of mercury having proved in this case so considerable, the experiment was repeated with chlorid of sodium; and even with this more stable salt it appeared that decomposition to some extent could be brought about. After ignition, the NaCl dissolved in a little water, reacted strongly alkaline to test paper, although the quantity of caustic soda formed was obviously not any larger, and the crucible did not seem to be attacked.

The method of Berzelius, therefore, thus applied, will not serve for the accurate separation of lithia and magnesia. The porcelain crucibles might be replaced by platinum ones, but lithia, acts, as is well known, with great energy upon platinum, and the vessels used would at least be seriously injured, even

were we to go to the further trouble of removing from the magnesia obtained in the process any platinum which had been dissolved off by the caustic alkali. But chlorid of magnesium is decomposed by oxyd of mercury, even during the evaporation of the solution; and it remains to be seen whether this mere evaporation, at a temperature not exceeding 212°, may not suffice for the complete conversion of MgCl into MgO, LiCl remaining unchanged. Ignition would then remove the excess of HgO from the MgO, and the HgCl formed from the evaporated filtrate.

(*To be continued.*)

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *Electrodynamic measurements.*—KOHLRAUSCH and WEBER have presented to the royal Saxon Academy of Sciences a memoir on the reduction of the electrodynamic, magnetic, and electrolytic measures of current-intensity to mechanical measure. The measure of current-intensity is the intensity of that current which under the normal conditions produces the unit of measurable action. The normal conditions for the magnetic action of a current are as follows: *the current passes through a circular conductor which includes the unit of surface, and acts upon a magnet which possesses the unit of magnetism from an arbitrary but great distance* $= R$; *the center of the magnet lies in the plane of the conductor and its magnetic axis is directed toward the center of the circular conductor.* The moment of rotation D exerted by the current upon the magnet is different under these circumstances, according to the difference in the intensity of the current, as well as according to the distance R; but the product R^3D depends only on the intensity of the current, and is therefore the measurable action of the current, so that the measure of the current-intensity is the intensity of the current whose measurable action under the conditions described is given by the equation

$$R^3D=1.$$

This measure of current-intensity is at the same time the intensity of the current, which, when it flows around a plane of the unit of surface, exerts at a distance an action equal to that of a magnet placed in the center of the plane, having the unit of magnetism, and with its magnetic axis perpendicular to the plane; or it is also the intensity of the current by which a *tangent's-compass with a single circle of radius* R is held in equilibrium, with a deviation from the magnetic meridian

$$\varphi = \text{arc tan}\frac{2\pi}{RT}$$

where T represents the horizontal component of the earth's magnetism.

The normal conditions for observations of the electro-dynamic actions of a current are as follows: *the same current passes through two circular*

conductors, of which each one includes the unit of surface, and which lie at an arbitrary but great distance $=R$ from each other: the line of intersection of the two circular planes at right angles to each other halves the first circular conductor. In this case, as above, the moment of rotation D depends upon the intensity of the current as well as upon the distance R, while the product R^3D depends only on the intensity of the current.

For observation of the electrolytic action of a current the normal conditions are as follows: *the current passes through water during an arbitrary accurately measurable time T, without undergoing any change in intensity.* The number of milligrammes of water decomposed by the current M, varies with the intensity of the current and the time T; but the quotient $\frac{M}{T}$ depends only on the intensity of the current, so that the measure of current-intensity is here the intensity of the current whose measurable action under the normal conditions is

$$\frac{M}{T}=1.$$

It remains to make these three measures comparable with each other. The comparison of the two first may be deduced from the general laws of electrodynamics, and Weber has already found (Electrodynamic measurements, ii, 261) that the first measure is to the second as $\sqrt{2}:1$. By a direct comparison of the electrolytic and magnetic action of the same current it was found that the third measure of current-intensity or the intensity of the current which decomposes 1 milligramme of water in 1 second is $106\frac{2}{3}$ times greater than the first measure.

The intensity of an electrical current may be determined not only from its action but also from its causes. The immediate causes of an electric current lie in the mass of the neutral electric fluid which is contained in a closed conductor, and in the velocity with which its two constituents, the positive and negative fluids simultaneously move in opposite directions. The mechanical measure of current-intensity is based upon these causes and may be expressed as follows. The mechanical measure of the intensity of the current is the intensity of that current which is produced by a velocity of the two electric fluids, such that the mass of each fluid which flows through the section of the conductor divided by the time in which it flows $=1$. The unit of quantity of positive electricity is here the quantity which when concentrated upon a point exercises upon an equal quantity of electricity at the distance of 1 millimeter a force which during one second communicates to the mass of 1 milligramme the velocity of 1 millimeter in a second.

The problem which the authors proposed to solve was to determine the quantity of electricity which flows through the section of the conductor in the unit of time in a current whose intensity is determined in units of magnetic, electrodynamic or electrolytic action. This quantity of electricity must be determined by the magnitude of the electrostatic fundamental force which it exerts. In other words, the intensity of such a current is to be compared with the quantity of electricity upon each of two small equally charged spheres which repel each other with the unit of force at the unit of distance, the unit of force being defined as above.

The method adopted by the authors for the solution of this problem was as follows. When a quantity of electricity E accumulated upon an insulated conductor is discharged to the earth through the wire of a galvanometer, it exerts during its passage a moment of rotation upon the needle. If the time of discharge be so increased, by introducing a column of water, that no discharge takes place between the windings of the wire, this time will still be only a very small fraction of the time of vibration of the needle. The action of the discharge upon the needle may therefore be regarded as an *impulse*, hence from an observation of the first elongation of the needle after the discharge, the angular velocity communicated to the needle may be determined by the laws of vibration, and this angular velocity will depend only on the quantity of electricity E.

With a constant current we may communicate a similar influence to the needle of the same galvanometer, if we allow the current to act only a very short time. The same quantity of electricity flows through the conductor in the time t with the intensity i as in the time $\frac{t}{n}$ with the greater intensity ni. Hence in this case also the angular velocity of the needle and consequently its elongation depends simply on the quantity of electricity which flows through a section of the wire during the passage of the current.

If now with the same galvanometer we produce equal elongations of the needle, at one time by the discharge of a known quantity E of positive electricity, and at another by a constant current of short duration, we may conclude that for the quantity of positive electricity x which flowed through the section of the conductor during which the short duration of the constant current

$$x = \frac{1}{2}E.$$

With these premises the solution of the problem rests on the two following points:

1. To measure the quantity of electricity E in the given electrostatic measure, and to observe the elongation of the needle of a galvanometer.

2. To determine the short time τ during which a constant current of intensity $=1$ (in magnetic measure) must pass through the multiplier of the same galvanometer in order to communicate the same elongation to the needle.

With respect to the second point, no particular experiments are required to determine τ, since the value of τ may be determined by calculation from the number and dimensions of the windings of the galvanometer, from the elongation of the tangent's-compass during the discharge and from the intensity of the earth's magnetism, much more accurately than by direct experiments. The determination of the quantity of electricity E requires a combination of several experiments. A large quantity of electricity is first to be divided into two parts in a previously determined ratio; the larger part is then discharged through the tangent's-compass to observe its magnetic action; while the smaller portion is measured by a Coulomb's torsion balance.

A Leyden jar whose outer coating was connected with the earth, was used as a source of electricity. By means of a Smee's-electrometer the

author determined the relation between the charge of the jar before and after contact with a large sphere, and consequently the ratio of the residual charge in the jar to that of the sphere. The large sphere being then brought in contact with the fixed ball of the torsion balance, the quantity of electricity communicated was calculated from the ratio of the radii of the spheres. Proper corrections were introduced for the loss of electricity arising from various causes. Our limits do not permit us to give the details of the author's very elaborate experiments, and we must therefore content ourselves with a statement of their results. The most striking of these results are as follows.

The magnetic measure of current-intensity is $155370 . 10^6$ greater than the mechanical measure.

Since, as already stated, the magnetic measure is to the electro-dynamic measure as $\sqrt{2} : 1$, the electro-dynamic measure of current-intensity is $109860 . 10^6$ $(=155370 . 10^6 . \sqrt{\frac{1}{2}})$ greater than the mechanical measure.

The magnetic measure is to the electrolytic measure as $1 : 106\frac{2}{3}$, consequently the electrolytic measure of current-intensity is $16573 . 10^9$ $(=106\frac{2}{3} . 155370 . 10^6)$ times greater than the mechanical measure.

These results are applied by the authors to several interesting cases, of which however, our limits will permit us to notice but two. These are the determination of the quantity of electricity necessary to separate 1 milligramme of hydrogen from 9 milligrammes of water, and the determination of the absolute force required to separate with a given velocity the oxygen and hydrogen in 1 milligramme of water. The authors find that to separate 1 milligramme of hydrogen from 9 milligrammes of water, $149157 . 10^9$ units—as defined above—are necessary. If such a quantity of positive electricity were accumulated in a cloud and an equal quantity of negative electricity concentrated upon the part of the earth's surface situated vertically under it, the result would be an attraction of the cloud by the earth, which at a distance between the two of 1000 meters would be equal to a weight of 45000 hundred weight or 2268000 kilogrammes. With respect to the force required to separate the oxygen and hydrogen of 1 milligramme of water, the authors find that if all the particles of hydrogen in 1 milligramme of water in the form of a column 1 millimeter long, were attached to a thread, and if all the particles of oxygen were attached to another thread, the two threads would have to be drawn in opposite directions each with a force of

147830 kilogrammes,

or about 2956 hundred weight in order to produce a decomposition of the water with the velocity with which 1 milligramme of water would be decomposed in a second. The tension would be proportionally less if the water were decomposed with a less velocity.—*Abhandlungen der mathematisch-physischen Classe der Königlich Sächsischen Gesellschaft der Wissenschaften. Leipzig*, 1856.

2. *On Boron.*—Wöhler and Deville have published the results of a very interesting investigation of this substance, which proves like carbon to have at least three allotropic modifications, two crystalline and one amorphous. The first of these modifications is the diamond-like boron which crystallizes in complicated aggregations of numerous small crystals,

the form of which has not yet been determined. These crystals are sometimes garnet-red and sometimes honey-yellow; the color however does not appear to be essential and may arise from slight impurities. The crystals have a lustre and refractive power like that of the diamond. They scratch corundum with the greatest ease and appear to be almost, if not quite, as hard as the diamond itself. Crystallized boron resists the action of oxygen even on strong heating, but at the temperature at which diamond burns, boron oxydizes superficially. Chlorine acts powerfully on boron which takes fire at a red heat in an atmosphere of the gas and burns to gaseous chlorid of boron. No acid acts upon boron, but acid sulphate of potash at a red heat reduces it, sulphurous acid being evolved. Hydrate and carbonate of soda oxydize it slowly at a red heat, but saltpeter has no action at this temperature. The preparation of crystallized boron is as follows: 80 grm. of aluminum in thick pieces are fused in a crucible of carbon with 100 grm. of fused and pulverized boric acid. The carbon crucible is placed in one of graphite, the interstices being filled up, and the whole heated in a wind furnace to the temperature at which nickel melts, for five hours. The crucible after cooling is found to contain two layers, of which one consists of boric acid and alumina, the other of alumina penetrated with crystallized boron. The metallic layer is heated with boiling soda lye to dissolve the aluminum, then with muriatic acid, and lastly with a mixture of nitric and fluohydric acids. The boron so obtained contains small plates of aluminum which can only be removed by mechanical means.

The second modification is the graphitoid boron which is best obtained by heating fluoborate of potassium with aluminum. Small masses of boron-aluminum are obtained, which on solution in muriatic acid leave the boron in small plates, often hexagonal and having the form and lustre of native graphite and graphitoid silicon. The plates are always opaque. Amorphous boron is best prepared by heating a small piece of aluminum with a large quantity of boric acid, purifying the product as above. It is a light chocolate-brown substance, possessing all the properties described by Berzelius, Gay Lussac and Thenard. The authors conclude that boron resembles carbon more closely than silicon.—*Ann. der Chemie und Pharmacie*, ci, 113. W. G.

3. *Notice of a supposed new case of Fluorescence;* by Prof. J. W. Mallet, (Communicated.)—A solution of thionurate of ammonia was boiled with muriatic acid for conversion into uramile. The solution after boiling exhibited very distinctly the phenomenon of "fluorescence" or "true internal dispersion" of Stokes. The modified light emerging from the liquid was of the same beautiful pale blue tint as that observable with solutions of quinine—most distinctly observable in the case of the mother liquor from which crystals of Herapath's iodo-disulphate of quinine have separated, a very little of which mother liquor suffices to render a large quantity of water fluorescent.

University of Alabama, Feb. 16, 1857.

II. GEOLOGY.

1. *Volcanic Action on Hawaii;* by Rev. T. COAN, (letter dated, Hilo, Oct. 22, 1856.)—During the whole of the past year, Lua Pele, (Kilauea) has been getting more and more profoundly asleep. A little sluggish lava is found in the great pit of Halemaemae (the old lake in the south-east part of the pit) and the steam issues from a thousand vents. But there is no subsidence of the floor of the crater. This vast area of hardened lavas keeps its elevation some 600 feet above the level of the floor that was formed at the eruption of 1840. * * *

I will now speak of the present eruption from Mauna Loa, which I have visited seven times, with ample opportunities for observation, besides enquiring of scores of other visitors. The apparent facts are these.

A fracture or fractures occurred near the summit of the mountain, which extended in an irregular line from the terminal point, say five miles down the northeast slope of the mountain. From this serrated and yawning fissure, for two to thirty yards wide, the molten flood rushed out and spread laterally for four or five miles, filling the ravines, flowing over the plains, and covering all those high regions, from 10 to 100 or 200 feet deep. Along this extended fissure, elongated cones were formed at the points of the greatest activity. These cones appear as if split through their larger diameter, the inner sides being perpendicular or overhanging, jagged, and hung with stalactites, draped with filamentous vitrifactions, and encrusted with sulphur, sulphate of lime, and other salts.

The outsides of these caves are inclined plains, on an angle of 40° to 60°, and composed of pumice, cinder, volcanic sand, tufa, etc. You will not, however, understand that these semi-cones were once entire, and that they have been *rent.* They are simply masses or ridges of cinder and dross deposited on each side of the fractures where the action is greatest, and where the greatest amount of fusion has been ejected. These ridges or scorified heaps and their substrata, together with the immense fields of refrigerated and uneven lavas for miles around, were all produced by ejections or *overflowings* from the fissures mentioned. *It is all a new deposit.*

While these immense floodings were going on laterally around the volcanic vents, incandescent streams were, of course, wiading their way down the side of the mountain. These fiery streams, when united, formed a river some three miles wide on the side of the mountain, and in the plains at the base of the mountain it spread into a lake or sea, from five to eight miles broad. Again it narrowed to two or three miles and went into the woods, winding its way through the thicket, contracting and expanding, and eating the jungle till it came within five miles of Hilo. Now, after you leave the region of open fissures, near the summit of the mountain all below *appears to be a flow on the surface.*

1st. We can *see* no chasms or fractures except those always found in the surface flows. There is no visible evidence that the old substrata had been fractured, except on the higher regions of the mountain.

2d. Where there is a throat extending down to the fiery abyss below, there will, we think, always be a column of smoke and gaseous vapor ascending to mark the spot, so long as action continues. This is true of

Kilauea, and it is also true of *all* the eruptions I have noticed. Now if you were in Hilo, you would see a continuous volume of smoke ascending from the terminal point and another from the terminus of the stream —separated in a direct line forty miles, and by route of the flow seventy miles—while between these extreme points you see no smoke and have no evidence of fire* beneath, except the radiation of heat as you pass up, or cross and recross this immense stream of solidified lavas. The smoke at the fountain is *mineral*—that at the end of the stream is from *vegetation*, and *only* here the fusion now makes its appearance, pressing on its way into the woods—having come, as I believe, all the way from the mountain *under cover*, without showing itself at a single point. I do not mean that it has *tunneled* the mountain, or melted a lateral duct through its mural sides. The process is thus: lavas flowing on the surface and exposed to the atmosphere, unless moving with great velocity, as down steep hills, soon refrigerate on the surface, as water freezes first on the top. This hardened surface thickens, until it extends downward 1, 10, 50, 100 or 200 feet, as the case may be. Under this superstratum the lava remains liquid, the hardened cover protecting the fused stratum from the refrigerating influence of the atmosphere, and thus facilitating its longitudinal or lateral progress. Consequently, at the termini, and sometimes along the margins of the hardened streams, you see the fusion gushing out in red lines and points, and in irregular masses; and, where the ground is not steep, pushing sluggishly on, like the creeping of a slug, or by paroxysmal throes. When lavas refrigerate through the whole stratum, and thus rest upon an ancient or previous formation, they form dams, or obstructions, which divert the stream of lava from above, unless this obstruction is lifted, broken up, tilted or overflowed by fresh supplies of lava. Down the steep sides of the mountain such obstructions occur more rarely; consequently, after a few days of wide spreading over these high regions, and when the superficial hardening process is completed, the lava ceases to reach the surface, either at the fountain or down the sides of the mountain, but is confined to channels, mostly covered with fresh, solidified lavas—where it finds a free and rapid passage to the plains below. Here the movement is slow, the obstructions more numerous, and the force to overcome them less potent. This accounts for the spreading laterally, the upliftings, the tiltings, the vertical gushings, the submergings, the fractures, pits, domes, ridges, little cones, and the ten thousand irregularities which diversify the ever changing surface of lava streams, while the fusion is struggling to work its passage, or to keep open its ever choking channels below, i. e. between its own crust and the former surface of the earth. I have seen a dome, some 300 feet in diameter at base, raised 100 feet high, and split from the summit in numerous radii, through which the red and vicid fusion was seen; and I have mounted to the top of such a dome, in this state, thrust my pole into the liquid fire and measured the thickness of its shell, which was from two to five feet. Now this dome, which

* This has been the case for some eight months. At first the whole ridge of the mountain was lighted with fusion on the surface. When the hardening and blackening process had progressed, light was seen at a few points only on the slope of the mountain. Afterwards no fire was seen except at the end of the stream near Hilo.

may be represented by an egg standing on its larger end, was full of liquid lava, visible and tangible, through the cracked shell of which you could thrust a pole to great depth into the fusion. This dome, with thousands of similar ones, of various sizes, was formed simply by hydrostatic pressure. This force, and that of vapors formed by the combustion of vast quantities of trees and other vegetable matter, submerged by the mineral river, produce the marvellous and mighty effects seen on the surface of the lava stream. Wherever vegetable matter is being consumed, there is smoke; when this is exhausted, there is none. Consequently I argue that there are no fissures extending to the central fires of the earth, except for a few miles near the summit of the mountain.

3d. Again, and what is more reliable, I have surveyed the ground upon which lava streams have been approaching, for distances of five, ten, fifteen, or twenty miles, and have seen the burning flood move on, covering to-day, the ground on which I travelled yesterday, and consuming the hut where I slept; and the process is so familiar, that it is difficult to see how I can be mistaken. It is as if you poured millions of tons of pitch upon a mountain, and stationed men in front and on the sides to mark its flow. Or it is as if an enormous water fountain opened on an Arctic mountain, congealing as it flowed and covering the whole region with accumulating glaciers. Calculate for the greater consistency of yonder mineral liquid and you may account for the varied phenomena.

I *think* that this stream of lava is *now flowing* more than 60 miles longitudinally, under its own refrigerated cover; but I may be mistaken. No fire is *seen* any where except near the end of the stream. Here it still pushes out and spreads and heaps with little abatement, while the great mountain furnace sends up large and continuous volumes of smoke. A wonder this, and a problem for geologists. The preservation of Hilo is marvellous.

2. *Geological Survey of Wisconsin;* (communicated by I. A. Lapham.)—The legislature of the State of Wisconsin at its late session appropriated $36,000 to be expended under the direction of Professors James Hall, E. S. Carr and E. Daniels in continuing the Geological Survey of that State. In addition to the geology proper, they are to examine, analyze, and classify the soils and subsoils, with a view to ascertain their adaptation to particular crops, and the best method of preserving and increasing their fertility; also to collect the soils, native fertilizers, cultivated and other useful plants (as well as the rocks, minerals, &c.), and deposit them in the rooms of the State University at Madison, to constitute a museum of practical and scientific geology.

3. *On the Reactions of the alkaline silicates;* by T. Sterry Hunt.—(From a letter to J. D. Dana, dated Montreal, April 2d, 1857.)—I have lately been engaged in studying the reactions of the alkaline silicates with the carbonates of magnesia and iron. We have long known that carbonate of lime and alumina have the power to remove silica from a solution of soluble glass; and I find that when a mixture of silica and carbonate of magnesia is boiled with carbonate of soda, the silicate of soda at first formed is decomposed by the magnesian carbonate and the regenerated carbonate of soda is enabled to dissolve a new portion of silica, the result being a silicatization of the magnesia through the intervention of the alkali.

With soluble silica (as prepared by igniting the silica from the decomposition of an alkaline silicate), this reaction is very rapid, and even when pulverized quartz is boiled for several hours with carbonates of soda and magnesia, a large amount of magnesian silicate is formed. If we substitute proto-carbonate of iron and boil it with soluble silica and carbonate of soda, there is formed a hydrous silicate of the protoxyd permanent in the air.

It will be apparent that by virtue of the power of earthy carbonates to decompose an alkaline silicate, and that of the regenerated carbonate of soda to dissolve silica even in the form of quartz, a small amount of alkali may effect the combination of a great quantity of silica with earthy bases.

Suppose a solution of alkaline silicate, which will never be wanting among sediments where feldspar exists, to be diffused through a mixture of siliceous matter and earthy carbonate, and we have with a temperature of 212° F. and perhaps less, all the conditions necessary for the conversion of the sedimentary mass into pyroxenite, diallage, serpentine, talc, rhodonite, all which constitute beds in our metamorphic strata. Add to the above the presence of aluminous matter and you have the elements of chlorite, garnet and epidote. We have here the explanation of the metamorphism of the Silurian strata of the Green Mountain range, and I believe of rock metamorphism in general.

I have just communicated a detailed account of my investigations to the Royal Society of London, and will soon furnish you with farther observations.

III. BOTANY.

1. *Musci Boreali-Americani, sive Specimina Exsiccata Muscorum in Americæ Rebuspublicis Fœderatis detectorum, conjunctis studiis* W. S. Sullivant et L. Lesquereux. Columbi Ohioensium; sumptibus auctorum, 1856.—The importance of authentically named specimens, in the study of Cryptogamous plants especially, cannot be over-rated; and among the Mosses, distinguished as so many species are by nice characters, very difficult to be expressed in words, the student cannot really get on without them. The present publication of specimens will therefore be eagerly welcomed and much sought after, alike by students just entering upon a charming branch of botany, and by our more advanced cultivators of Bryology. For the latter, the simple announcement of the publication of this collection is sufficient. For the benefit of those not so well informed upon the subject, we may state, that the value and importance of these sets of specimens are greatly enhanced by the fact that they have been all studied and named by the author of the Muscology of the United States (east of the Mississippi), comprised in Gray's *Manual of Botany* (the only book in which our Mosses are described at all),—aided by his excellent coadjutor, M. Lesquereux,—that they are accordingly specimens of *the very things* described in that work; and that the sets are so complete that they comprise almost all the species of Musci (or true Mosses) contained in the Manual. On this account, as well as on account of the care with which the specimens have been selected, and their general copiousness, we may be permitted to say that these published sets are unsurpassed, if not wholly unequalled, by any previous muscological collection ever issued. The numbers on the printed

tickets extend to 355; but the many intercalated numbers (e. g. 10^b, 10^c, 100^b, 100^c, 100^d, etc.) raise the total to about 416 species or marked varieties. The specimens are mounted on small pieces of white paper to which the printed label is affixed, and laid in folded sheets of brown paper of folio size; a title page and complete Index of names and synonyms, filling two folio sheets, are appended, and the whole placed between strong covers bearing an additional title, tied up so as to form a convenient portfolio. Additional specimens of fully half the species are added to each set, left unattached, for more convenient examination, but enclosed in paper capsules, bearing the number to which each belongs: and it should be noted that these enclosed specimens are generally more perfect and choice than those which are glued to the paper. The proprietors, according to their fancy, may keep the specimens as they are, or may mount them in any way they prefer, and bind them in one or more folio volumes. The price of the sets, having before publication been announced at $20, when it was supposed that the number of specimens would hardly reach 350, has not been raised; but it probably must be somewhat increased after the sets now in readiness are taken up. They are put up by Mr. Leo Lesquereux, of Columbus, Ohio, and sold by him, to recover a portion of the expense of collection and preparation. (Purchasers may likewise order sets through Prof. A. Gray of Cambridge, Mass.) That the spirit of the authors may be appreciated, we venture to mention,—at the risk of violating a confidential communication,—that the sets of this collection (supposing the whole edition to be demanded) have each cost in actual outlay about twice as much as they are sold for. A. G.

2. *Fungi Caroliniani Exsiccati;* by H. W. Ravenel. Fasc. IV.—The general remarks made upon Fasc. III. of this Collection will very well apply to this. In fullness, neatness, and general accuracy, it is equal to the preceding Number, and offers to Mycologists a very interesting century of North American Fungi. There are about 65 species exclusively American, besides *Trichocoma paradoxa*, Jungh., previously known only as an East Indian species. We might perhaps question a few of the species, but it would not be well to designate them without a more careful comparison than we have been able to make. Occasional errors are to be looked for in a work of this kind, and will be readily pardoned by all who are familiar with this obscure order of plants. They will doubtless be rectified in a critical Index of some future fascicle. We remark, in correction of our notice of fasc. III, that *Polyporus dealbatus* of that collection (which, in consequence of a temporary confusion in our Herbarium, we referred to *P. luteus*, Nees), is *P. mutabilis*, Berk. and Curt.; as Mr. Ravenel had himself suggested to us before publication. M. A. C.

3. *First Lessons in Botany and Vegetable Physiology*, illustrated by over 360 wood engravings, from original drawings, by Isaac Sprague: With a Glossary or Dictionary of botanical terms; by Professor Asa Gray. New York: G. P. Putnam & Co., and Ivison & Phinney. 1857. —Good elementary books in any branch of science are rare, while poor compilations are common enough. In the department of Natural History, for example, nothing is more easy than to gather from all quarters a mass of crude materials, and with the aid of old plates and drawings, suited only to a different latitude and designed for another purpose,

to make up cheap books, to the great profit of compiler and publisher, and the great loss of the young in whose hands no works except those of the highest character should be placed. Indeed, a good text-book of science, like a picture or a poem, is a work of art, the creation of which requires extensive knowledge, abundant resources and a generous and enthusiastic love of nature. And, even where these exist, none but a master can rightly sieze the leading facts and principles and exhibit them in language at once precise, clear and simple—can be brief without being obscure and thorough without being prolix—can so fashion his teachings as to charm the youthful mind and lead it on imperceptibly into the very heart of the science—can furnish fresh and original illustrations of familiar objects in drawings and engravings, and give them that perfect accuracy which only an eye trained to a close scrutiny of forms can fully appreciate. Hence really excellent elementary books are rare indeed.

There is a special satisfaction, therefore, when these requisites are fulfilled, as is true in the case of the "First Lessons in Botany and Vegetable Physiology" from the pen of Dr. Gray. It is a model of its kind; and meeting a want long and widely felt, it must sooner or later win its way into all our schools and seminaries of learning. After a chapter on the general relations of the science, it treats of the growth of the plant from the seed,—the nature of roots, stems and leaves,—the arrangement of the leaves, structure of the flower and functions of the several parts,—the fruit—vegetable tissues and the process of growth, or nutrition and circulation—the permanency of species—classification;—and closes with practical instruction on the best method of studying and collecting specimens and making herbaria. It comes to the beginner as a pleasant and easy stepping-stone to the larger "Botanical Text-Book," and from either, the student passes over to the "Manual of the Botany of the Northern United States," prepared to study our wild plants with advantage. Two impressions of the latter work have been lately published, one at a lower price than the other, for the express use of colleges and schools, the little studied portion on the Mosses and Liverworts being omitted for the sake of cheapness and convenience. Considering the intrinsic value of these books, the great care, labor and talent which have been devoted to their preparation, the good style in which they are published, and the great number and excellence of their illustrations (from drawings by Mr. Sprague), the wonder is, that they can be sold at so moderate rates. We trust that they may meet with a circulation, proportioned to their real merit. T. C. P.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

Correspondence of M. Jerome Nicklès, dated January 3, 1857.

1. *Electric illumination.*—A few weeks since, some experiments on electric illumination were made at Paris, surpassing all that had before been done. The success was due to an electric regulator invented by MM. Lacassagne and Thiers, called by them an *electro-metric* repeater. It is complicated in structure and cannot well be described here. The inventors placed four of their electric lamps on the platform of the Arc de Triomphe de l'Etoile, and projected the light one day on the Champs

Elysées, towards the Place de la Concorde, and a second on the avenues of Neuilly or de l'Impératrice, the change having been made because of the numerous gas lights of the Champs Elysées. These gas lights were made to look dull and smoky, yet diminished the effect of the electric light; but in the avenues of l'Impératrice the light presented intense brilliancy.

Each lamp was sustained by means of sixty of Bunsen's pairs, and furnished with a spherical reflector of metal, or of glass silvered by a battery in the manner described beyond.

2. *New Battery with a constant current.*—For some time a battery has been known having an improvement for economizing the residues. It was invented by Mr. Doat, an amateur of Alby (Department of Tarn). In this battery, the zinc is replaced by mercury, the acidulated water by iodid of potassium; the nitric acid or sulphate of copper of the batteries with two liquids, by iodine dissolved in the iodid of potassium, and which, put in to excess in the solid state, serves to maintain constant action. Carbon is employed as the negative pole. A square trough of gutta percha contains the mercury and the alkaline iodid. The carbon and the iodized iodid are put in a square porous cup which is immersed in the liquid of the trough to two centimeters above the level of the mercury.

This battery once in action, requires no other care than that of drawing off with a glass siphon the liquid saturated with iodid of mercury, which is to be restored to its primitive elements. We shall soon explain the method of restoration. The couple, as it was presented to the Academy of Sciences by Becquerel, possessed a feeble electro-motive force. It was but little stronger than a couple with sulphate of copper, and only one-third that of a couple with nitric acid. Its force was such that for a trough of about five decimeters square, and with a thickness for the bed of iodid of potassium of about three centimeters, it was equivalent to ten meters and a half of annealed copper wire one millimeter in diameter, this wire being at 0° C. in temperature.

The process adopted by Mr. Doat for economizing the residues admiting of some improvement, he has made changes which have increased the power of his batteries. The main point consists in substituting zinc amalgam for mercury; he obtains thence iodid of zinc, and the restoration of this compound to its elements, which at first appeared difficult, he has rendered easy by using a hydrated carbonate of copper. Whilst the soluble salts of oxyd of copper in reacting on the alkaline iodids precipitate only one-half, the basic salts, and especially the carbonate, exercise hardly a sensible action on the alkaline iodids, but act with the greatest rapidity on the alkaline-earthy or metallic iodids, and eliminate the whole of the iodine, the oxyd passing to the state of a suboxyd, and the metal combining with the iodine becoming oxydized. This action, which goes on rapidly at the ordinary temperature, is instantaneous at 50° C.

On the flat carbon pole, there is placed a broad filter of porous earth, containing hydrated carbonate of copper. When the battery has been for a while in action, the liquid, consisting of double iodid of zinc and potassium, is drawn from the troughs and thrown upon the filter, where it is decomposed by the copper salt. The alkaline iodid remains pure and

the iodid of zinc is changed into an oxyd of this metal, whilst the iodine set at liberty is dissolved in the alkaline iodid, and passes with it through the filter and falls upon the carbon pole. Thus the processes for recovering the iodine requires only the drawing off the liquid and putting it in a filter charged with hydrated carbonate of copper. The products left on the filter are oxyd of zinc and carbonate of copper. They are mixed with charcoal and fused at a red heat. The result is a brass always in demand in commerce. The hydrated carbonate of copper is prepared by double decomposition by means of sulphate of copper and carbonate of soda. The latter is the only product which is lost: all the others, the iodine, iodid of potassium, mercury, zinc and copper, are re-obtained and may serve again in the battery or be useful elsewhere.

Mr. Doat does not perform the reduction of the zinc and copper except when it can be done on a large scale; for he then obtains a casting of brass, of greater commercial value.

3. *A Battery, called a Battery with triple contact.*—One element of this battery consists of a glass or stone ware cup, at the bottom of which there is a plate of non-amalgamated zinc communicating without by means of a conducting strip. Above the plate of zinc there is a spiral formed of a rolled copper plate having an attachment for making connections. A solution of sulphate of potash covers entirely a plate of zinc, and wets to a certain height the plate of copper. Immediately on making the connections between the copper and zinc, an electric current is established which continues constant for several weeks.

The inventor of this battery is an Italian, Francesco Selmi, Professor of Chemistry in the University of Turin. The novel and important point of it is the triple contact, viz. between the sulphate of potash and zinc, the sulphate of potash and copper, and between the copper and the air. Prof. Selmi has observed that there is a great advantage in this contact of the air with the copper immersed in the sulphate of potash, finding that the electric current is sensibly weakened when the copper is wet throughout.

4. *Nautical Telegraph.*—In place of the common light used as a beacon and for signals aboard ships, Mr. Trève proposes to substitute a simpler system more easy of execution. It is based on the use of illuminating gas light by a galvanic current of induction. The lamp at the mast head receives the gas through a tube of vulcanized caoutchouc having a spiral of copper wire within, and covered exteriorly by some impermeable material; it terminates on the deck where the gasometer is placed. By stop-cocks, the gas can be let in at will. A Ruhmkorff's apparatus* is used for inflaming the gas; two wires covered with gutta percha pass to the upper lamp. These wires branch off and are attached to the shank of each of the other lamps; and are so arranged as to give a spark at the beak of each burner. As the light will take place only at the beaks supplied with gas, the lights may be varied for signals by means of stop-cocks, any or all of the lamps being lighted or extinguished at will.

5. *Light-houses and Illumination.—Lenses and Reflectors.*—It is well known that Buffon, desirous to repeat the experiment of Archimedes with a burning glass, endeavored to construct a lens of water of large diameter.

* See this Journal, Jan. 1853, p. 114.

Two plates of glass of great thickness were curved by the heat of a concave metallic plate, worked and polished, and then fitted together with a border of metal and filled with distilled water. Buffon thus made a lens one meter in diameter and of great power. But he pursued it no further, because of the difficulty of the work, and the enormous expense of polishing the rough surfaces of the glass, the material being also rendered brittle by the second heating.

Since then, in England and more lately in France, there have been attempts to blow a glass lens in a mould of metal made in two halves. But the result has been imperfect, the glass uneven, giving no distinct focus. There has however been a recent improvement by Messieurs Lemolt and Robert, which is of great importance. It consists in using for constructing the lenses, a circular plate of glass, and a section from a sphere blown with great care, applying this to the plate and closing them together in a circle of metal, and putting water between or some other transparent liquid. It forms a plano-convex lens, which may be economically made, and has the purity and perfection nearly, without the cost, of lenses of massive glass.

Lemolt and Robert have also made improvements in reflectors, employing sections of glass more or less concave, cut from a sphere, in the same way as above mentioned, and having on the convex part a rich plating of silver from electric deposition. These reflectors can be cheaply made and require little care.

Lenses and reflectors of this kind have been used on the railroads of Paris. By combining the two, a new kind of lamp has been constructed, giving results of unexpected brilliancy, which have already been brought into use on board ships and at the entrances of ports as well as on railroads. A water lens of 38 centimeters will send its rays to a distance of 20 kilometers along a railway, producing the effect of a light-house light of the second order.

6. *Manufacture of Soda.*—Mr. Melsens, Professor of Chemistry at Brussels,—known for his works on chemistry and also in connection with the preparation of anhydrous acetic acid by means of bi-acetate of soda, the production of the chlorated bodies by means of an amalgam of sodium, etc.,—has patented a new method for the manufacture of soda, a process of great importance, if it be economical. It is based on the well known fact of the decomposition of sulphate of soda by carbonate of baryta. An equivalent of the former with one of the latter produces two-thirds of an equivalent of each carbonate of baryta and sulphate of baryta; one-third of an equivalent of each carbonate of baryta and sulphate of soda remaining unaltered.

Melsens has observed that the change will go on in the cold and with native carbonate of baryta, and this is the basis of his method.

This carbonate is powdered and subjected to a washing by means of a solution of sulphate of soda. This mode of washing, for a long time practised in the arts, enables him to obtain the carbonate of soda in a state of considerable concentration. Some little sulphate of soda however remains, which may be separated either by crystallization or by taking advantage of the fact that sulphate of soda is more soluble in water at 33° C. than in boiling water, it precipitating when the water is

carried to the boiling point. The purification is finished by putting the liquid in contact with a solution of carbonate of baryta in carbonic acid. Mr. Melsens has also endeavored to decompose the carbonate of baryta and sulphate of soda by using high pressure furnished by a self-regulating machine. But no advantage has been found in this process.

As the carbonate of baryta is poisonous, it is proposed to pulverize it after moistening it with a solution of sulphate of soda. The sulphate of baryta obtained in the process is employed either in the manufacture of paper, or for paints, this last a use not honest perhaps, but yet, in these days, of extensive application.

7. *Astronomical News.—Paris Observatory.*—The observatory at Paris continues to make progress. It is well known that it has two wings, an eastern and a western; on the former, in the time of Arago, a revolving chamber for observation was constructed, whose mechanism is a chef-d'œuvre. The western wing is about to receive a telescope of the largest dimensions, at the expense of the government, and also an equatorial with a 11-inch aperture, constructed by Secrétan.

The objective of the telescope will be constructed with two disks of flint glass and crown glass, cast in the glass house of Chance & Co., Oldbury near Birmingham, which were on exhibition at the Crystal Palace in Paris. These glasses were imperfectly appreciated by the jury, for it was thought that after extracting certain portions that were not perfectly transparent and remelting them several times, they would not afford an objective over 40 centimeters in diameter. They were however deemed irreproachable and were purchased for 50,000 francs; and it is now expected that the objective made from them will have a diameter of 73 centimeters. The work will be carried on at the observatory by M. Secrétan. If the curvature obtained be perfect, the achromatism without fault, and the expected size be attained, France will have the most powerful lens in the world.

8. *Color of the Moon during eclipses.*—Prof. Faye, of the Faculty of Sciences at Nancy, observed a fact during the last eclipse of the moon, which serves to explain the peculiar color assumed by the moon when under the shadow of the earth. By covering the part not eclipsed by a distant object, such as the angle of a roof or the top of a chimney, the tint of the part eclipsed is entirely changed, and in place of a reddish-brown there is seen only a lively rose-red, like that which is so common on clouds near sunrise or sunset and which gave origin to the epithet rosy-fingered (ῥοδοδακτυλος) applied to the dawn. The color seen ordinarily in case of eclipse is consequently an effect of contrast, due to the usual yellowish shade of the moon's light.

9. *Works of Arago.*—The third volume of the Popular Astronomy has just appeared and is on sale with the first and second. While the second volume contains a fine study on the sun illustrated with five plates of the solar spots, and a treatise on comets followed by a catalogue of all that have been calculated to the number of nearly 200, the *third* takes up the subject of the earth and its satellite. The earth is described not only astronomically, but also with reference to its geology, meteorology, physical geography, and even history; and under these heads it treats of the age of mountains and volcanoes. It also discusses the question

whether the deluge was produced by a comet,—whether the moon was once a comet,—whether the moon has an atmosphere or water,—what influence has the moon on the earth's atmosphere, and what on animated life and especially certain diseases,—and the subject of *prognostics.* The volume closes with an article on eclipses and occultations. The work contains many drawings, and a fine map of the moon, and also an engraving representing the meridian telescope of the Paris Observatory. The *fourth* volume will soon be issued.

10. *Influence of Temperature on the phenomena of Capillarity.*—The influence of temperature on capillarity, considered null by some authors, is still real. Lalande was the first to announce it, in 1768; he showed that water did not stand as high when it was hot, or when the tube had been heated before making the experiment. Laplace and Poisson deduced from it that the height had some relation to the density of the liquid. Emmett, Frankenheim, Sondhauss, Frankenberg, Brunner, Jurin, Gay Lussac, Simon de Metz, Bède, Professor at the University of Liège, have each treated of this question, and from their results a wide divergence has been brought about between mathematical theory and experiment, and a complete separation of the phenomena of ascension and depression.

All these questions have been taken up from their foundation and definitely resolved by the laborious researches of M. Wolf, Professor of Physics at the Lyceum of Strasburg, which have been continued through several years. The following are the facts arrived at:—

(1.) The elevation of the same liquid in capillary tubes depends, other things equal, on the nature of the tube.

(2.) In the same tube, at different temperatures, the height to which a liquid rises is in the compound proportion of the density and the curvature of the meniscus; this diminishes as the temperature increases and becomes null at some specific temperature beyond which, the action is the reverse. The law of variation of pressure with the temperature for liquids which do not wet the glass, thus connects with the law of diminution of capillary elevation, and becomes a consequence of it. For if, at a given temperature, a liquid ceases to wet the glass, beyond this temperature the liquid takes a convex surface and depresses itself; whence it follows, that liquids like mercury not wetting the glass at the ordinary temperature, can wet it at a temperature quite low, and so present under the action of cold the same series of phenomena which ether presents under that of heat.

11. *Harmonic proportions of the human body.*—This subject interests both men of science and artists. It has often been objected to the metric system that it had no point in common with the human body, and differed thus widely from the older systems. M. Silberman has undertaken to demonstrate that the meter may also be found on the body of man.

At the introduction of this system, it was remarked that a cane a meter long, resting on the ground between the feet, would reach quite nearly to the height of the navel. By noting the discrepancy by the breadth of the fingers, each one may thus have his own meter measure with him.

M. Silberman, from the many measurements that have been made, concludes that the mean height of man is 1·64 meters. Buffon makes the

height of woman one-twentieth less, so that the mean of both sexes will be 1·60 meters, and of woman 1·56 meters.

The size of man is often expressed by the number of heads it equals; and in a person well proportioned it corresponds to 8 heads. The mean height of the head will consequently be 20 centimeters. Mr. Silberman has observed that when the arms are thrown up vertically, the height of the body to the tip of the middle finger is 10 heads or 2 meters, and two men in a line, would make 4 meters. He remarks that this length of 4 meters or 20 heads plays an important part in nature; and after various observations, he has arrived at a number of laws as to the proportions in the human body. Thus the distances of the articulations are successively, $\frac{1}{3}$, $\frac{1}{6}$, $\frac{1}{27}$, $\frac{1}{81}$, $\frac{1}{243}$, &c. [The account is not sufficiently explicit to make it clear how or where these proportions are all obtained.] Silbermann states that the results he has arrived at accord with those of the ancients, who paid much attention to the subject. It is generally admitted for example, that in a well proportioned man, when both arms are extended horizontally, the distance between the tips of the fingers, is just equal to the total height of the man. Another fact, mentioned by Vitruvius, as a test of perfection of form, is this: that the circle which passes by the extremities of the four members extended in a cross, should have the navel as the center. These facts are confirmed by M. Silbermann.

12. *Bibliography.—Astronomie Populaire d'Arago*, vol. iii, and *Notices Scientifiques*, vol. iii. Paris. Gide et Baudry.—The first of these works we have noticed. The second work treats of light-houses, fortifications, artesian borings, filtration and elevation of water, free exchange, protection and patents.

Victor Masson has issued—

Etudes Biographiques pour servir à l'Histoire des Sciences, by Paul Antoine Cap. 1 vol. 12mo, of 408 pages.—This work is the first part of a series of biographical notices of chemists and naturalists. The volume issued, treats of Paracelsus, Palissy, Van Helmont, Moses Charas, Robert Boyle, Lemery, Rouelle, Van Mons, Labarraque, Bernard Courtois, Dupasquier, etc. The notices are well written and in an agreeable style.

Hydrotimétrie, ou Nouvelle Méthode pour déterminer les proportions des matières en dissolution dans les eaux de sources et de rivières, by MM. Boutron and Boudet. Pamphlet of 52 pp. 8vo.—Starting from the precipitation of calcareous salts by soap water, a reaction applied first by Clarke to the determination of lime, MM. Boutron and Boudet have contrived a quick method for ascertaining by means of a few trials the essential composition of a potable water. It is performed by means of standard solutions, and is simple, requiring little chemical knowledge.

L'Ozone, ou Recherches chimiques, météorologiques, physiologiques et médicales sur l'oxygène électrisé; by H. Scoutetten, "Médecin en chef" of the hospital at Metz. 1 vol. in 12mo, of 287 pages.—Dr. Scoutetten has attached his name to the subject of ozone by many important observations. His work commences with a historical review. The importance of the subject and the great number and variety of papers that have appeared upon it had rendered it very desirable that a collection of these materials should be made in one volume. Dr. Scoutetten has undertaken this labor, and has given a succinct account of all the results that have been published.

At Baillière's, Rue Hautefeuille, Paris, has just appeared—*Etudes sur la géographie botanique de l'Europe et en particulier sur la végétation de plateau central de la France*, par M. Lecoq, Professeur à la Faculté des Sciences of Clermont.—This work, of which we have before spoken, is now at its 5th volume. No better writer on the geological or botanical description of the Central Plateau of France could be found than M. Lecoq, as he has there pursued his studies for thirty years. The 5th volume treats of a large number of the Dicotyledonous families, from the Papaveraceæ to the Leguminoseæ, including the Cruciferæ, the Polygaleæ, the Malvaceæ, etc. J. Nicklès.

13. *First Comet of* 1857, (Astr. Jour., March 31.)—A comet was discovered by Prof. d'Arrest, of Leipzic, February 22, 1857, its place then being at $16^h\ 40^m$ (Leips. m. t.) R. A. 320° 37′, and its N. decl. 22° 4′. The same comet was also detected on the 26th of March, by Mr. Van Arsdale at Newark, N. J., who describes it as bright and resembling an unresolved star-cluster. From observations of Feb. 22 and 25, Mr. Pape deduced the following elements.

March 14·088 Berlin m. t.

Long. of perihelion, ...	197° 0′·4
" " asc. node, ...	323 31·7
Inclination, ...	87 6·2
Log. perih. dist.	9·82586
Motion, ...	retrograde.

14. Obituary.—*Prof. Jacob W. Bailey.*—In our last number we had the melancholy duty of announcing the death of Mr. W. C. Redfield, the meteorologist; and before another month had elapsed, two more men from the ranks of science, highly esteemed for their excellence of character as well as successful labors, had passed away,—Prof. Bailey of West Point, and Prof. Tuomey of Alabama.

Prof. Bailey had long been failing under a relentless consumption, and finally died on Thursday, the 26th of February last. For many months his voice had been reduced to a whisper; yet his mind was active, and as late as our last number (March), we published a contribution to science from him, as the result of his recent microscopic researches. Feebleness of health prevented his being present at the meeting of the American Association at Albany in July last. But the Association in view of his high attainments and valuable researches, elected him President for the following year,—an honor well merited; for few men in the land have exerted a wider and more beneficial influence on the science of the country.

Prof. Bailey, although a proficient also in chemistry, mineralogy, and botany, had been especially devoted to microscopic research, and with the exception of what Ehrenberg has done, the microscopic geology or "microgeology" of this country has been mainly worked out by him. His first communication to this Journal, was published in 1837, and although chemical, it indicated that delicacy of manipulation which fitted him for microscopic researches. It related to the use of grasshoppers' legs as a substitute for frogs in galvanic experiments. In volume xxxv. (1839), commence his papers on fossil Infusoria, which were continued through many of the following volumes, down to the current year, and are too well known and appreciated to require remark at this time. The Continent

along its Atlantic and Pacific borders and over its interior has passed under his microscope, and delighted him with many beautiful forms of life which had never before greeted a human eye. And lately, the ocean's bottom in the Atlantic to a depth of 12000 feet, and about the North Pacific to 16000 feet, has developed wonderful facts before his investigations. Prof. Bailey has also done a vast deal towards raising the standard of microscope manufacture through his discriminating use of tests, and his influence. His scale for microscopic slides by which the positions of the invisible specimens are exactly noted, is a happy thought well carried out. In these and various other ways, microscopy is vastly indebted to his labors. Mr. Bailey at his death was Professor of Chemistry, Mineralogy and Geology in the U. S. Military Academy at West Point. His life without reproach, his gentleness and modesty, his earnestness for truth rather than self, his untiring energy even when his physical system seemed to be dissolving away from his spirit, make a character that excites love as well as admiration.

Prof. TUOMEY.—Prof. M. Tuomey died at Tuscaloosa on the 30th of March last. He had been one of the active geologists of the Southern States, and among them had taken the lead through his researches and publications. In 1844 he was put in charge of the Geological Survey of South Carolina, and four years afterward published his final Report in a large quarto volume. The Report treats of the various crystalline rocks and their metalliferous veins or ores, and dwells at length on the Cretaceous and Tertiary beds which had been with him more special subjects of study. In his survey, he brought out many facts of prominent interest, illustrating important principles in the geology of the continent and the history of seashore deposits.

The state of South Carolina is remarkable geologically for containing nothing of the carboniferous formation (unless metamorphosed); excepting the middle secondary red sandstone, which he traced from North Carolina to a distance of four or five miles into South Carolina where it is associated with trap dykes as in the Connecticut valley, there are no stratified rocks, yet observed, between the metamorphic beds and the Cretaceous.

Subsequently, Prof. Tuomey was appointed to the Chair of Geology of the University of Alabama at Tuscaloosa and to the charge of the Geological Survey of that State, which positions he held when he died. He had been actively engaged in his explorations during the year past, and both the State and the University have experienced a great loss in his decease. In connection with Dr. F. S. Holmes he has had in hand the publication of a splendid work on the Fossils of South Carolina, which has not been surpassed in the country for the beauty of its palæontological illustrations. Geological science is greatly indebted to Prof. Tuomey's zeal and fidelity, and has occasion for mourning that his labors have ceased.

Dr. SCORESBY, the veteran of Arctic enterprise, died at Torquay, England, on the 21st of March last, after a lingering illness.

15. *New Granada: Twenty Months in the Andes;* by ISAAC F. HOLTON, Professor of Chemistry and Natural History in Middlebury College. With maps and illustrations. New York, Harper & Brothers, 1857, pp. 605, 8vo.—If it fell within our province to review a book of travels, we

should speak of this as a very interesting one of its class, and as particularly rich in information of permanent value. But, what commends the volume to our attention is, that, along with the easy flow of entertaining narrative, there is an under-current of scientific observation, such as might be expected from a naturalist and chemist visiting a country so striking in its physical and climatic features. Of the vegetation, especially, Prof. Holton has succeeded in conveying to us, dwellers in northern climes, a very distinct conception, and that without any effort at description, and without much use of technical details. Should the work ever pass to a second edition, we advise the author to bring his great knowledge to bear upon this subject more directly and efficiently by adding a separate chapter on the Vegetation of New Granada, giving a comprehensive view of this flora in its main features, and in its distribution over the country according to climate, from the tropical sea-level up to the cold *paramos* and the isolated peaks clothed with perpetual snow.

Much to our surprise, the author speaks of the *Chirimoya*,—generally ranked among the three best tropical fruits of the world,—as little better than our *Asimina* or "Papaw;" which, moreover, he terms a congener, having through some oversight mistaken *Unona* for *Anona*. While suggesting corrections, we venture to question the physics and geology of a paragraph, commencing on p. 237,—the idea that the temperature of a higher *paramo* is at all dependent on the great thickness of the crust of the earth there than at the sea-level. We fear the author has not taken into account, the intensity of nocturnal radiation, and the more rapid evaporation under diminished pressure, as causes of refrigeration, as well as the dilatation of the air; and, on the other hand, has overlooked the fact that the neighborhood of active volcanoes, does not sensibly affect the temperature of a place. One word more upon another matter. As Prof. Holton's valuable work will be sure to find readers beyond the United States, we think it a disadvantage that words are used, now and then, in their New England rather than their general English sense, For example, the use of the word "town" for township, on p. 497, would inevitably lead an Englishman to conclude that our villages and small cities were rough and wild indeed.

16. *Memoir of John Dalton, and History of the Atomic Theory up to his time;* by Robt. Angus Smith, Ph.D., F.C.S. (Published also as vol. xiii, New Series, of the Memoirs of the Literary and Philosophical Society of Manchester). 298 pp., 8vo. London 1856, H. Baillière.—In the life of a philosopher or the history of a principle in philosophy, when either is faithfully executed, there is profound instruction. They not only teach us methods of research, but illustrate its true spirit and aim, and the secret of its strength. The young student will search the world over, unsuccessfully perhaps, for a subject for investigation. The philosopher finds a subject in the most familiar phenomena about him, and by steady scrutinizing labor, draws forth facts and principles of fundamental value. The history of Dalton and his atomic theory has for this reason as well as others a special value to the student in science. The work of Dr. Smith has a peculiar merit, from its bringing out Dalton's theory of atoms in its true relations to the speculations of former centuries. He treats briefly of the views on atoms among the ancient Greeks, and thence traces the

subject through the period of Alchemy and the earliest beginning of Chemistry to the development of Dalton himself when the mathematical basis of this science and its simple system of numbers were first made clear. A fine portrait of Dalton forms a frontispiece to the volume.

17. *Recent Papers by Prof. J. Leidy, M.D.*—Notice of Remains of the Walrus discovered on the Coast of the United States. Specimens were found on the sea beach of New Jersey: and the species appears to be the recent *Trichecus rosmorus*, probably of the drift or later post-tertiary period.—Description of Remains of Fishes from the Carboniferous limestone of Illinois and Missouri.—Remarks on *Saurocephalus* (Harlan) and its allies.—Observations on the extinct Peccary of North America. Dr. Leidy speaks of the large variations in the size and form of the skull and teeth of the recent *Dicotyles torquatus*, and afterwards remarks on the remains of the extinct Peccary and their variations; the one species *Dicotyles compressus* probably including the hitherto proposed species *Euchœrus* (*Protochœrus*) *macrops*, and *Protochœrus prismaticus*, *Platygonus compressus*, *Hyops depressifrons*, *Dicotyles depressifrons*, *Dicotyles costatus*.—Remarks on the Structure of the feet of Megalonyx.—From the Transactions of the American Philosophical Society, vol. xi, page 83 to page 106. Philadelphia, 1857.

18. *Millitary Map of Florida South of Tampa Bay;* with a memoir compiled by Lieut. J. C. Ives, Topog. Eng., under the general direction of Capt. A. A. Humphreys Topog. Eng., by order of the Hon. Jefferson Davis, Secretary of War, April 1856, War Department.

19. *Observations on the Physical Geography and Geology of the Coast of California, from Bodega Bay to San Diego;* by W. P. Blake; prepared for Prof. A. D. Bache, Superintendent of the United States Coast Survey, and published in the Report of the Coast Survey.

20. *Transactions of the Academy of Science at St. Louis;* 92 pp. 8vo. with plates, St. Louis, 1857.—This first number of the first volume of the St. Louis Academy promises much for the science of the country. The President of the Academy for 1857 is B. F. Shumard, M.D., the Vice Presidents, A. Wislizenus, M.D., and C. P. Chouteau. The first 36 pages are occupied with the Proceedings of the meetings, after which follow various important papers:—

1. J. Evans and B. F. Shumard: On some New Species of Fossils from the Cretaceous Formation of Nebraska Territory.
2. H. A. Prout: Description of a New Species of Productus from the Carboniferous limestone of St. Louis; with a plate.
3. J. Schiel: Observations on Glycerine.
4. T. C. Hilgard: Phyllotaxis, its numeric and divergential law, explicable under a simple organological idea; with a plate.
5. A. C. Koch: Mastodon Remains in the State of Missouri.
6. G. Seyffarth: Notice of a burnt brick from Nineveh; with a plate.
7. A. Wislizenus: Indian Stone Graves in Illinois.
8. B. F. Shumard: Description of New Fossil Crinoidea from the Palæozoic Rocks of the Western and Southern portions of the United States; with a plate.
9. A. Litton: Belcher & Brothers' Artesian Well; with a plate.

21. *Brechung und Reflexion des Lichts an Zwillingsflächen optisch einaxiger volkommen durchsichtiger Medien*, von Dr. Joseph Grailich, Privat-Docenten an der Wiener Universität. From the 9th volume of the Mathematico-natural History Section of the Royal Academy at Vienna. 1855 and 1856. Dr. Grailich is a profound mathematician and physicist, and in two papers has discussed the subject of the refraction and reflection of light in twin crystals with great ability.

22. *Abhandlungen der k. k. Geologischen Reichsanstalt*, Band III.—This 3d volume of Transactions from the Geological Survey of Austria or rather the Geological Department under the Austrian government, is occupied solely with a memoir on the Molluscan fossils of the Tertiary of Vienna by Dr. Moriz Hörnes with the assistance of Paul Partsch. It is a magnificent work in 736 quarto pages illustrated by 52 exquisite lithograph plates of crowded figures, the beauty of which can hardly be exceeded. This work is the first volume only of the memoir, treating of the Univalves. The Bivalves remain for another volume. Dr. Hörnes is "Custos. Adjunct" of the Royal Hof. Mineral Cabinet, of which Partsch is "Custos."

23. *Jahrbuch der k. k. Geol. Reichsanstalt*, 1855, No. 4, and 1856, No. 1.—This publication, is the Bulletin of the Geological Society of Vienna, containing numerous important geological papers, besides mining information. Each number, of which four appear annually, extends to between two and three hundred pages.

24. *Prodromus descriptionis Animalium Evertebratorum*, &c., of the North Pacific Expedition under Captain Rodgers, by W. Stimpson.—This pamphlet of 13 pages 8vo, contains brief descriptions by Mr. Stimpson of fifty-two species of *Turbellaria Dendrocœla* collected by him in the course of the North Pacific cruise on the Coasts of Asia and America, and adjoining islands.

C. F. Rammelsberg: Die neuesten Forschungen in der krystallographischen Chemie, as supplement to his Handbook on Crystallographic Chemistry, 227 pp. 8vo, with numerous woodcuts. Dr. Rammelsberg is performing an excellent service for science in collecting together the facts in crystallographic chemistry.

25. *Ruhmkorf's Apparatus constructed by E. S. Ritchie of Boston*, (From a letter to J. D. Dana from Prof. W. B. Rogers, dated Boston, April 16, 1857.)—You will I know be interested to learn that Mr. E. S. Ritchie, the well known instrument maker of this city, has succeeded in constructing a Ruhmkorf Induction Apparatus of such energy as greatly to surpass the Paris instruments, and, so far as I am acquainted with their action, to compare favorably with the recently improved form introduced in England. After encountering many difficulties in the insulation of the coil as well as the construction of the condenser and breakpiece, he has devised such arrangements in regard to each as to secure a dense continuous spark, between the terminals of the secondary wire, of from 2 to 2½ inches long, and to permit the means of exhibiting all the effects of the discharge on a scale and with a brilliancy truly superb.

The columns of light in vacuo transversely stratified or waved, Gassiot's cascade, and other effects which I have found it to produce, and which we have exhibited at the Warren Club and elsewhere, are among the most magnificent electrical displays which I have ever seen. The primary

current is developed by the action of four Bunsen cells of Deleuil's construction; the secondary wire is less than 1½ miles long.

This I believe is the first instrument of the kind yet made in this country, at least it is the first possessing such power; but Mr. Ritchie, not satisfied with his present success, is beginning the construction of another from which we anticipate even greater effects, and which we hope will be completed in time for description in your July number.

A. Keith Johnston: A new Dictionary of Geography, Descriptive, Physical, Statistical, and Historical, forming a complete general Gazetteer of the world. 2nd ed. thoroughly revised. One large volume of 1300 pages. London. 36*s.* cloth.

A. Keith Johnston: Physical Atlas. New edition containing Murchison's Geological Map of Europe, Rogers's Geological Map of the United States, and other new charts. London and Edinburgh. 1856.

Normos: An attempt to demonstrate a central law of Nature. London.

E. Chevreul: The Principles of harmony and contrast of colors and their applications to the Arts. Translated from the French by C. Martel. 2nd edition, crown 8vo. London. 10*s.* 6*d.*

Charles John Anderson: Lake Ngami; or Explorations and Discoveries in Southwestern Africa. 2nd ed., royal 8vo. London. 30*s.*

Henry Bradbury: The Ferns of Great Britain and Iceland, *nature printed.* In imperial folio. London. 6*l.* 6*s.*—A splendid volume of folio plates and text.

Henry Bradbury: Nature Printing, its origin and objects. London. Bradbury & Evans, 11 Bouverie Street.

T. Scheerer: An introduction to the use of the Blowpipe; translated with additions by H. T. Blanford. Leipsic and London. 1856.

J. G. Beer: Die Familie der Bromeliaceen. 269 pp. 8. Wien. 1856.

Dr. H. O. Lenz: Zologie der alten Griechen und Römer. 656 pp. 8vo. Gotha, 1856.

Dr. G. Meckel von Hemsbach: Mikrogeologie. Ueber die Concremente im thierischen Organismus. Herausgegeben von Dr. Th. Billroth. 275 pp. 8vo. Berlin, 1856.

Prof. J. Müller: Di Aequatorialzone des gestirnten Himmels, mit Text, Folio. Freiburg.

Dr. H. Burmeister: Systematische Uebersicht der Thiere Brasiliens, welche während einer Riese durch die Provinzen von Rio de Janeiro und Minas Geraes gesammelt und beobachtet wurden. III Thl. Vögel. 2. Hälfte. 466 pp. 8vo. Berlin.

C. G. Carus: Ueber Lebensmagnetismus und über die magischen Wirkungen überhaupt. 306 pp. 8vo. Leipzig.

Cyclopædia of Natural History. (Based upon the Penny Cyclopedia.) In four volumes, with many hundred illustrations. London. 2*l.* 2*s.* Also *Cyclopedia of Geography.* In four volumes. Ibid.—Excellent works.

Proceedings Boston Soc. Nat. Hist.—Vol. VI. p. 48. On the state in which phosphate of lime exists in Sea-water; *A. A. Hayes*—p. 51, Fossil bones of Elephant, Megatherium and Mastodon from Texas (adding a third, to the two known N. American localities of Megatherium, of Skiddaway Island on the coast of Georgia, and Ashley River in S. Carolina); *J. Wyman.*—p. 55, Observations on the structure of bone in Python; *J. Green.*—p. 56, Effect of bite of Rattlesnake on a Mouse; *J. Wyman.*—p. 57, Corrosion of shells of freshwater Clams; *D. F. Weinland.*—p. 59, On a new genus of Tænioids; *D. F. Weinland.*—p. 63, Observations on the Classification of Fishes; *L. Agassiz.*—p. 63, Notes on the classification of Turtles; *J. E. Mills.*—p. 67, On the relation of respiration to action of the heart, and on the suprarenal Capsules; *Brown-Séquard.*—p. 71, Note on Orangs of Africa; *W. A. Gibson.* p. 72, Note on the Blind fish of the Mammoth Cave; *J. Wyman.*—p. 73, Biographical notice of Dr. John C. Warren; *J. Wyman.*—p. 84, New species of Crustacea from Western North America; *W. Stimpson.*—p. 97, Catalogue of the Binney Library.—Analysis of Slate from Somerville, Mass.; *L. M. Dornbach.*—p. 108, On Vireosylvia; *T. M. Brewer.*—p. 112, On series in the Animal Kingdom; *D. F. Weinland.*—p. 114, List of Birds observed at Great Manan and at Yarmouth, N. S., with notes; *H. Bryant.*—p. 123, Species of N. Atlantic and Behrings Straits partly identical; *A. A. Gould.*—p. 125, Dissection of eye of Sperm Whale; *J. Wyman.*—p. 126, On the Zonda Wind; *N. H. Bishop.*—p. 128, On Helix asteriscus; *E. S. Morse.*

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